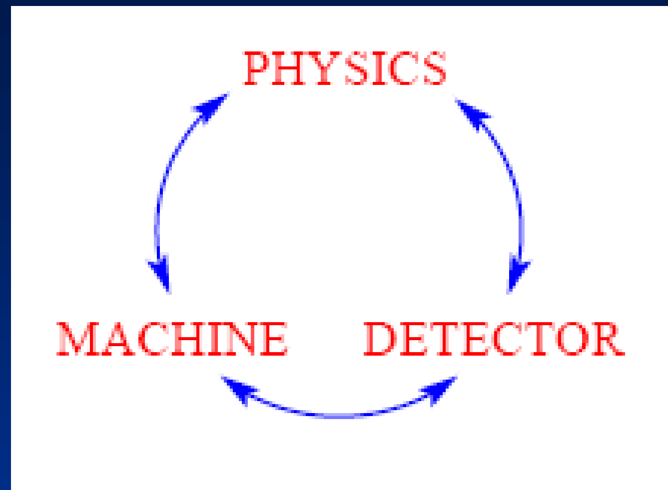
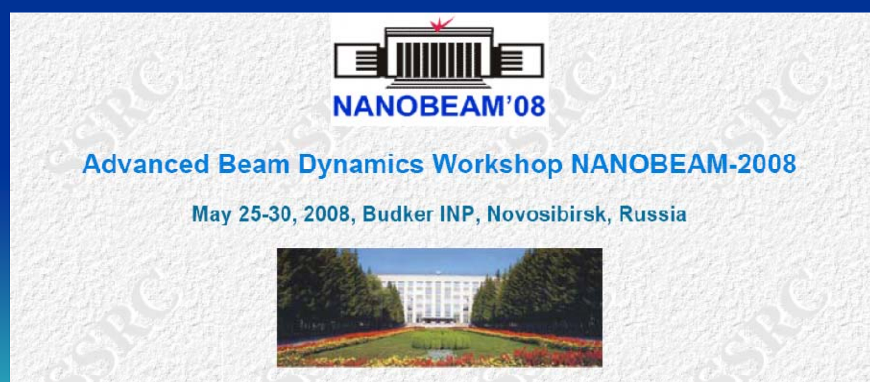
ILC Detectors and



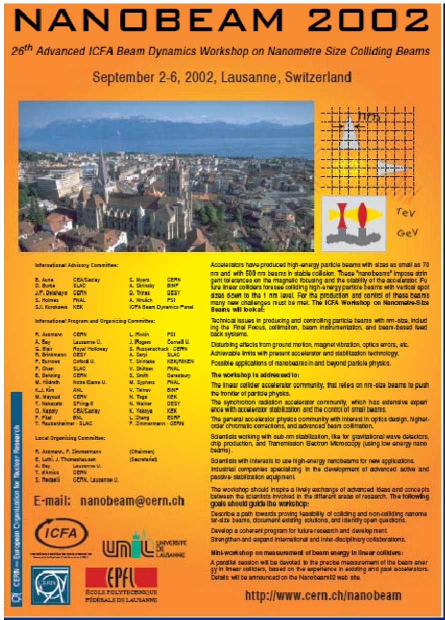
Detector View of MDI



Worldwide Study of the Physics and Detectors for Future Linear e+e- Colliders

Max-Planck-Institut für Physik (Werner-Heisenberg-Institut)

Ron Settles MPI-Munich
Nanobeam 2008 Workshop@BINP
26 May 2008

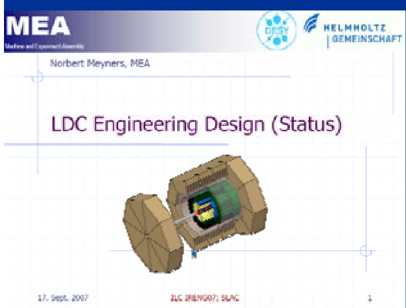


EUDET

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

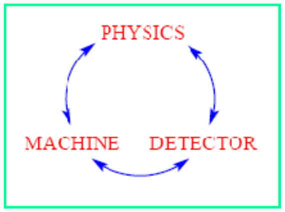
LC-TPC

CALICE
Calorimeter for ILC



ilc

This is the 3rd workshop in the series as we all know. Notice the blossoming of logos! And where does this one come from…



???

Global Design Effort

ILC INTERACTION REGION ENGINEERING DESIGN WORKSHOP   SLAC

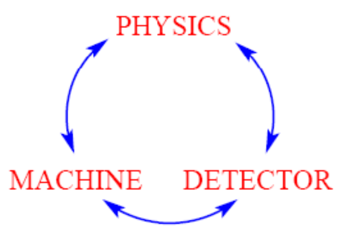
It started at the LC92,LC93 workshops in Garmisch-Partenkirchen,SLAC to emphasize the correlation between the three, and ended up in a contribution to Nanobeam02…

INTERACTION-REGION ISSUES

Ron Settles*, Max-Planck-Institut für Physik, 80805 Munich, Germany

Abstract

The jobs at hand concern everybody in the LC business. Establishing and controlling the e^+e^- luminosity at a level



of 10^{34} cm^{-2}s^{-1} in the interaction region (IR), i.e., from the final quadrupoles to the interaction point (IP), will require a sophisicated interplay of several technologies dealing with gymnastics on nanometer-sized colliding beams. An overview of the issues is given in this contribution to Session[4] of the Nanobeam Workshop[1]-[9].

…and I shall follow the circle clockwise for this talk:

0-Machine…

1-Physics…

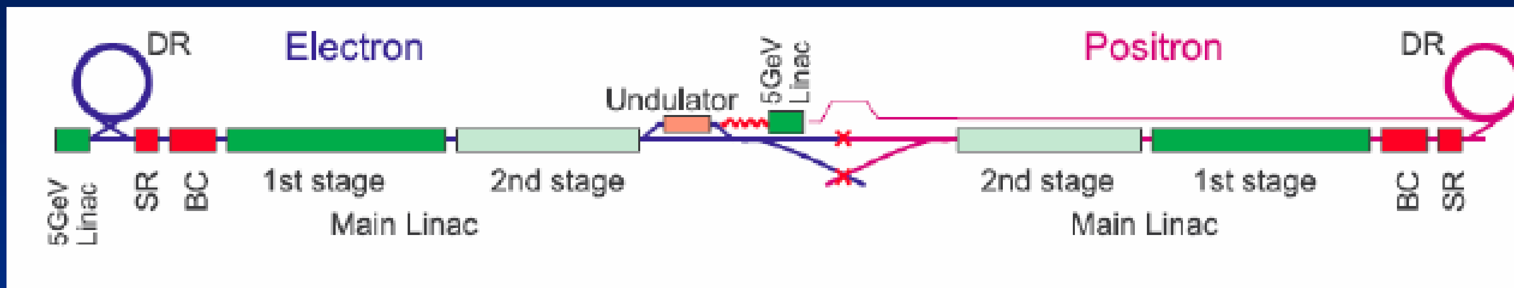
2-Detector…

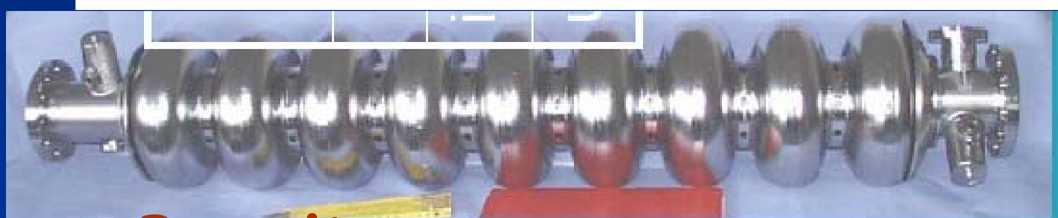
3-MDI…

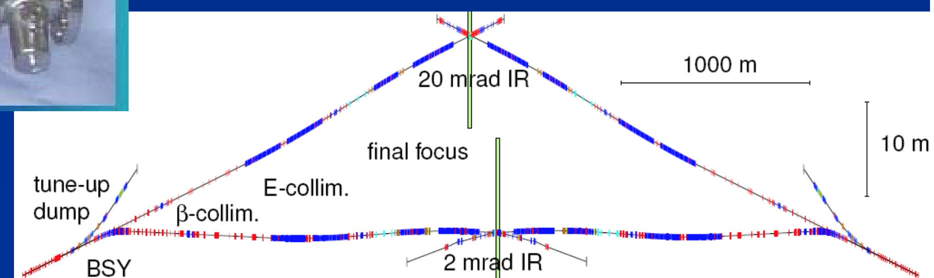
In addition to my own, I have borrowed some slides from several colleagues for this talk, to give a better feel for the activities…Thanks to them!

2005. ITRP Technology decision: COLD superconducting à la TESLA chosen

International Linear Collider



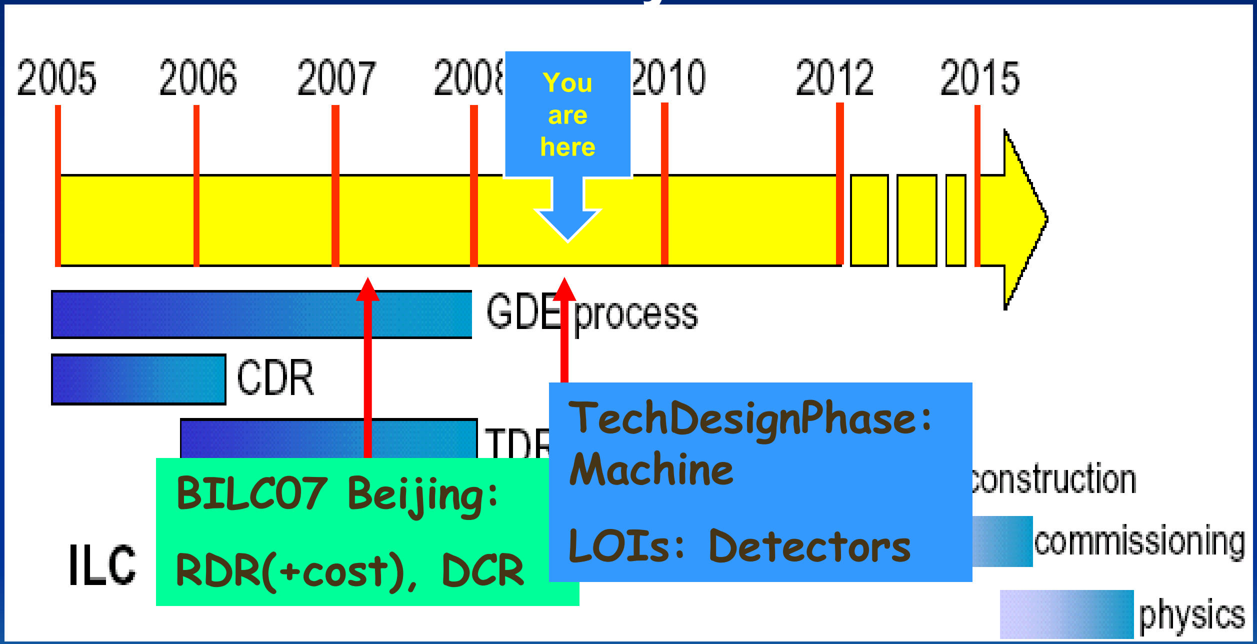




- **Baseline:**
- **200 GeV < √s < 500 GeV**
- **Integrated luminosity ~ 500 fb^{-1} in 4 years**
- **80 % e- beam polarisation**
- **Upgrade to 1TeV, ∫L = 1 ab^{-1} in 3 years**
- **2 interaction regions**
- **Concurrent running with the LHC from 2015**

The Global Design Effort

Formal organization began at LCWS 05 at Stanford in March 2005 when Barry became director of the GDE

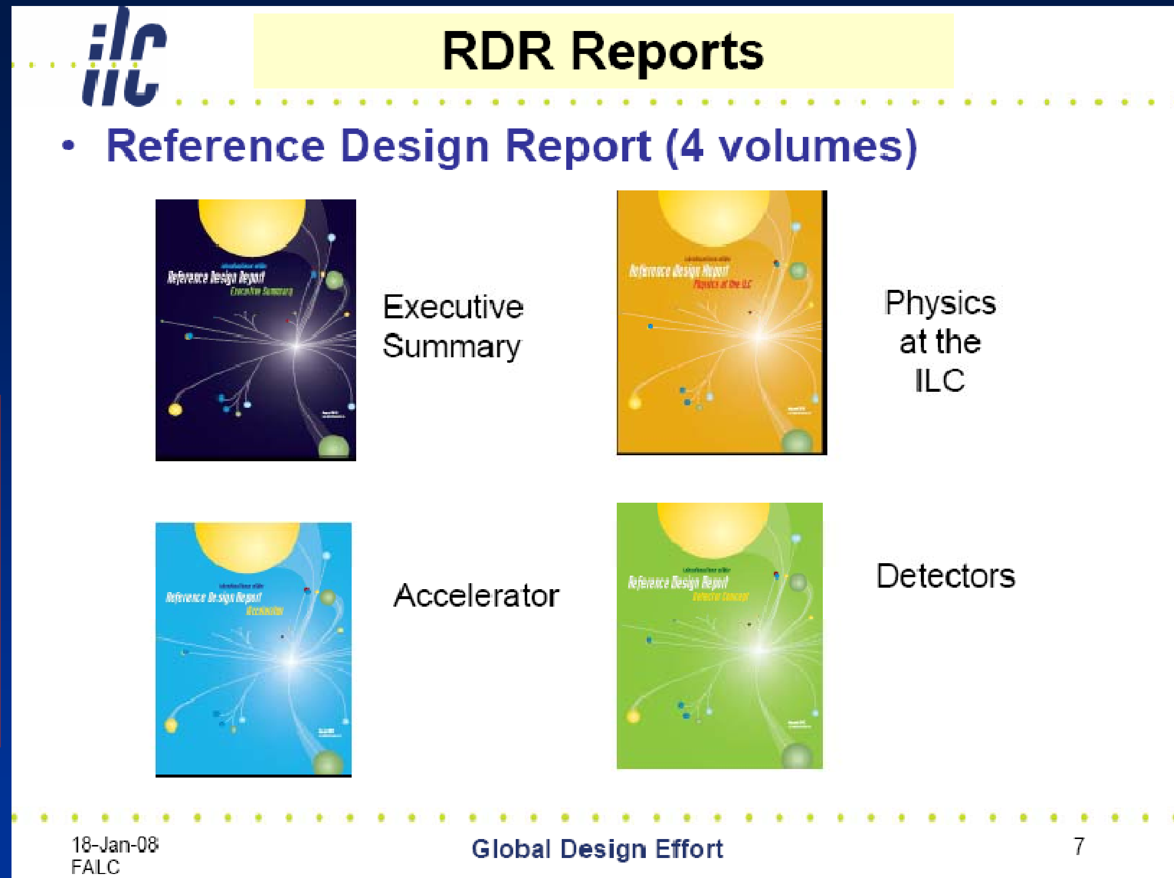


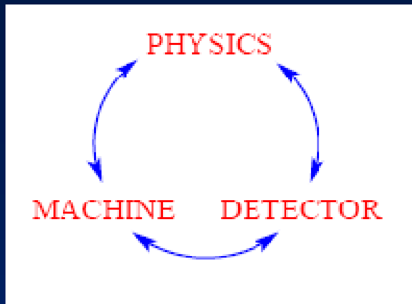
'Technically Driven Schedule' 2005,

very optimistic, but we have to be…

All the goals in the first timeline were met up to fall 2007!

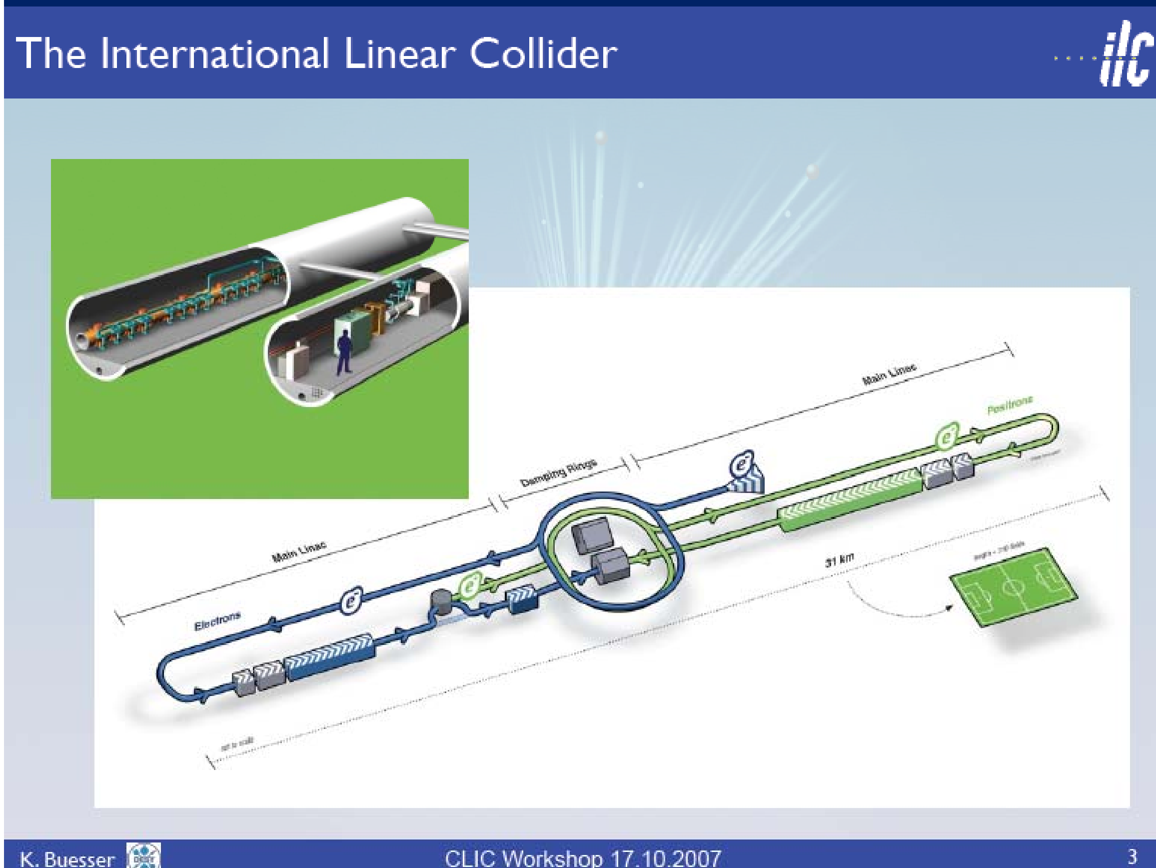
Then came financial problems…

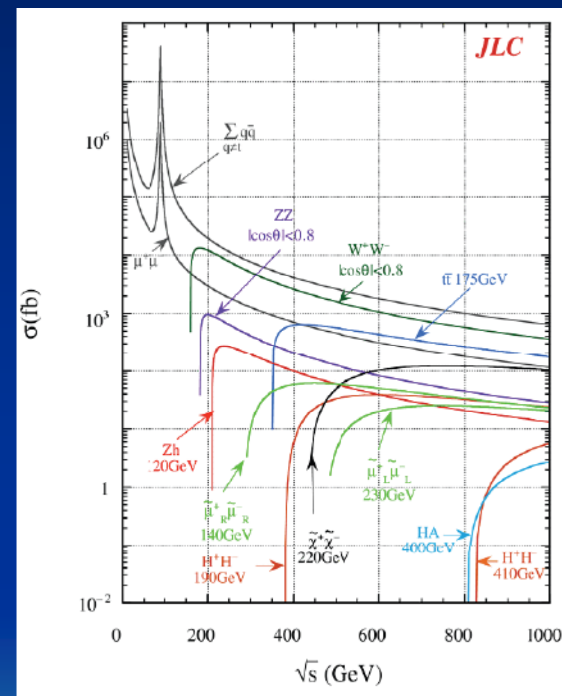




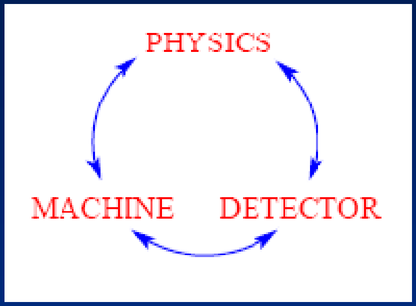
RDR Machine → Physics

(since detector design is driven by the physics, look at that first)





Machine->Physics… from my talk at the Arlington LC Workshop January 2003:



WHY LC?

TWO-PRONG ATTACK at LC on PHYSICS beyond the SM

→ INDIRECT

PRECISION MEASUREMENT

Higgs – Top – WW – $q\bar{q}$ – GZ – M_W

⇒ High statistics
⇒ Polarized beams

e.g., $M_{Z'} \sim$ 5 TeV

→ DIRECT

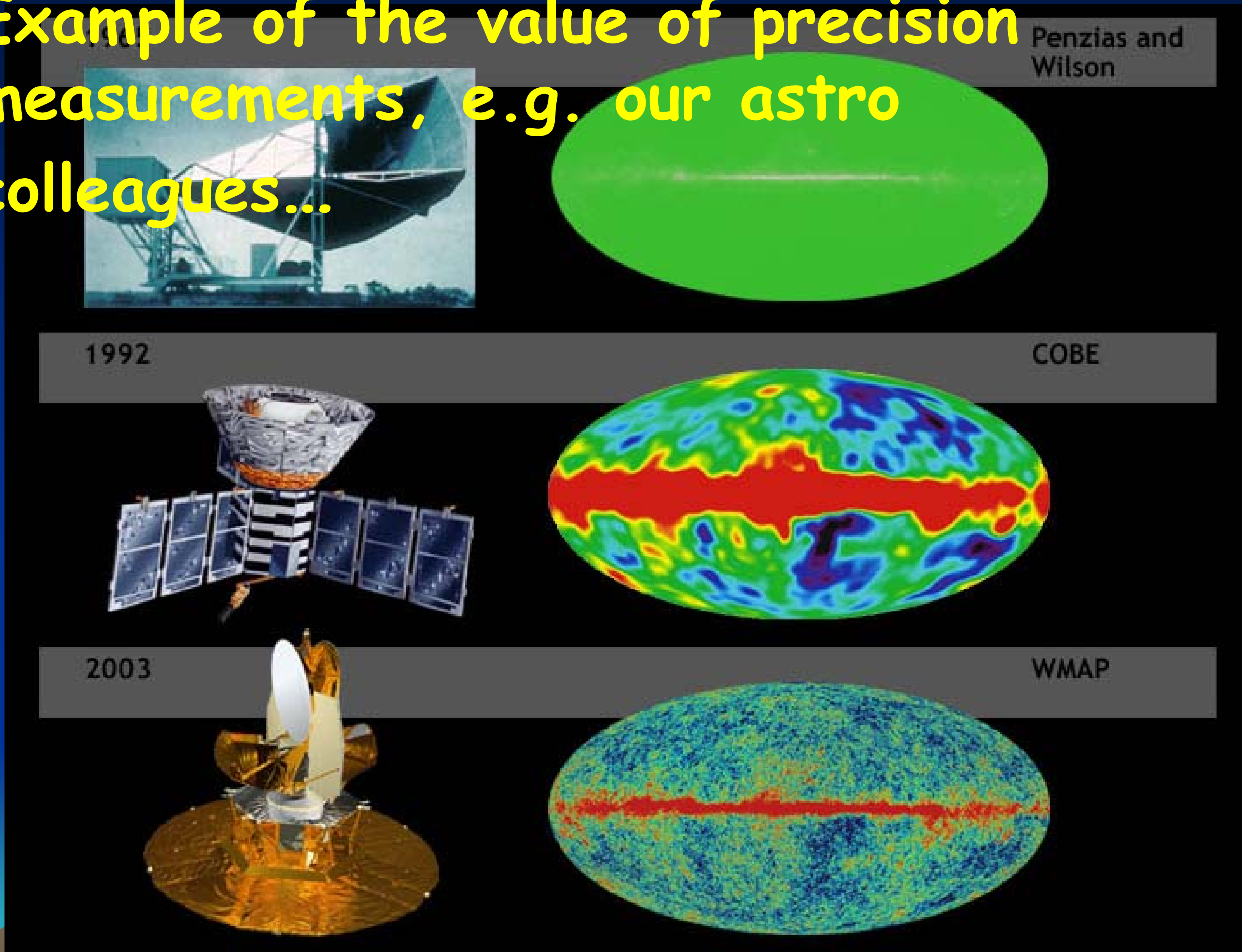
DISCOVERY

Susy – Alternative Theories

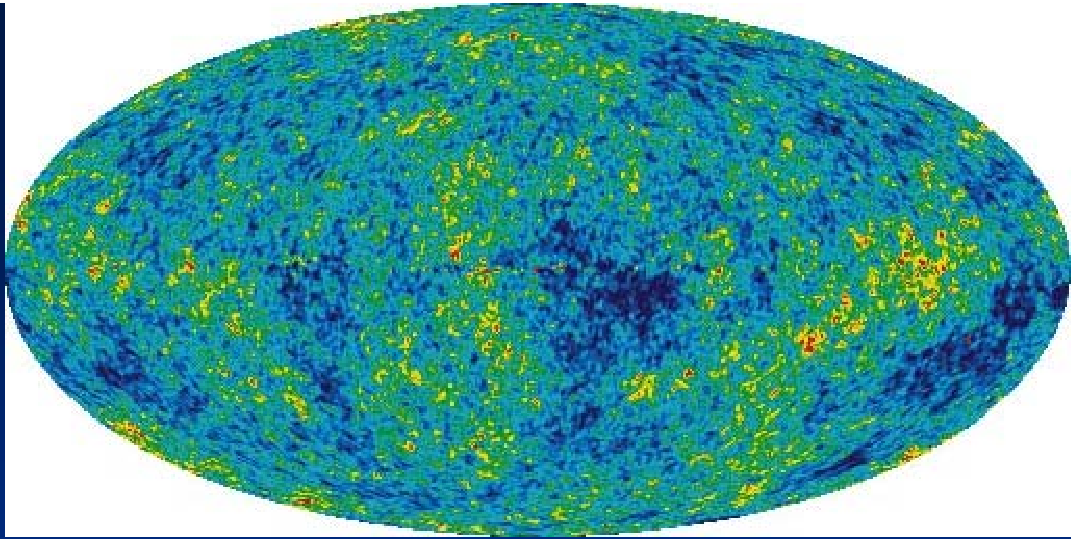
e.g., 'Susy Forest'

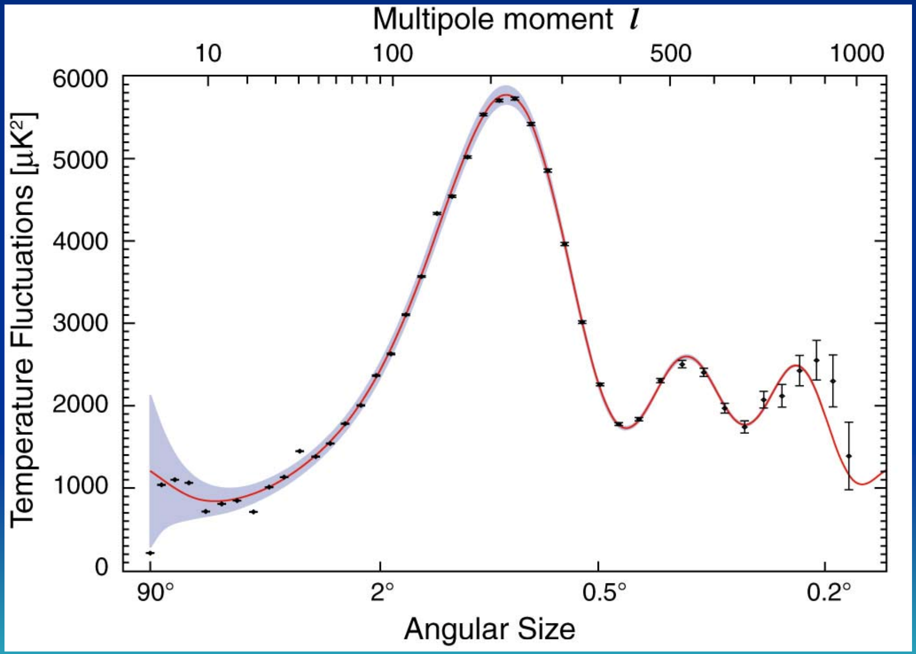
→ **<u>NECESSARY</u>** COMPLEMENT to LHC

Example of the value of precision measurements, e.g. our astro colleagues…



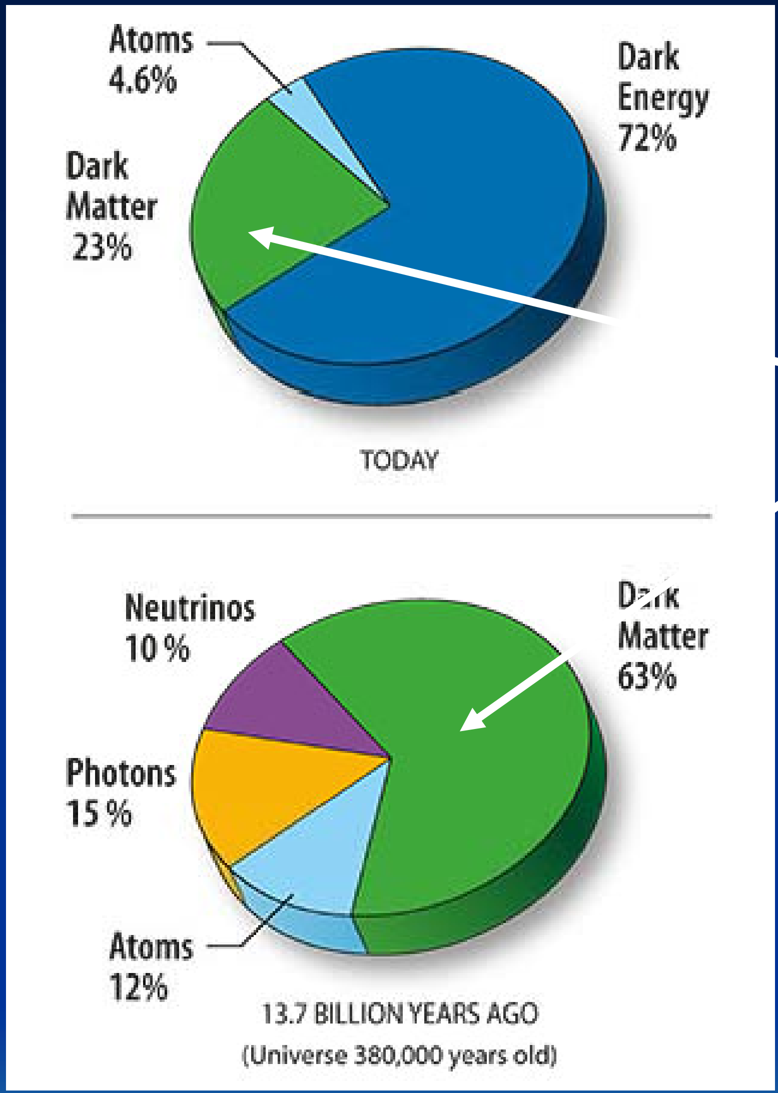
Latest '5-year' results





Multipole expansion: measure the structure of the fluctuations and…

...understand the composition of our universe:

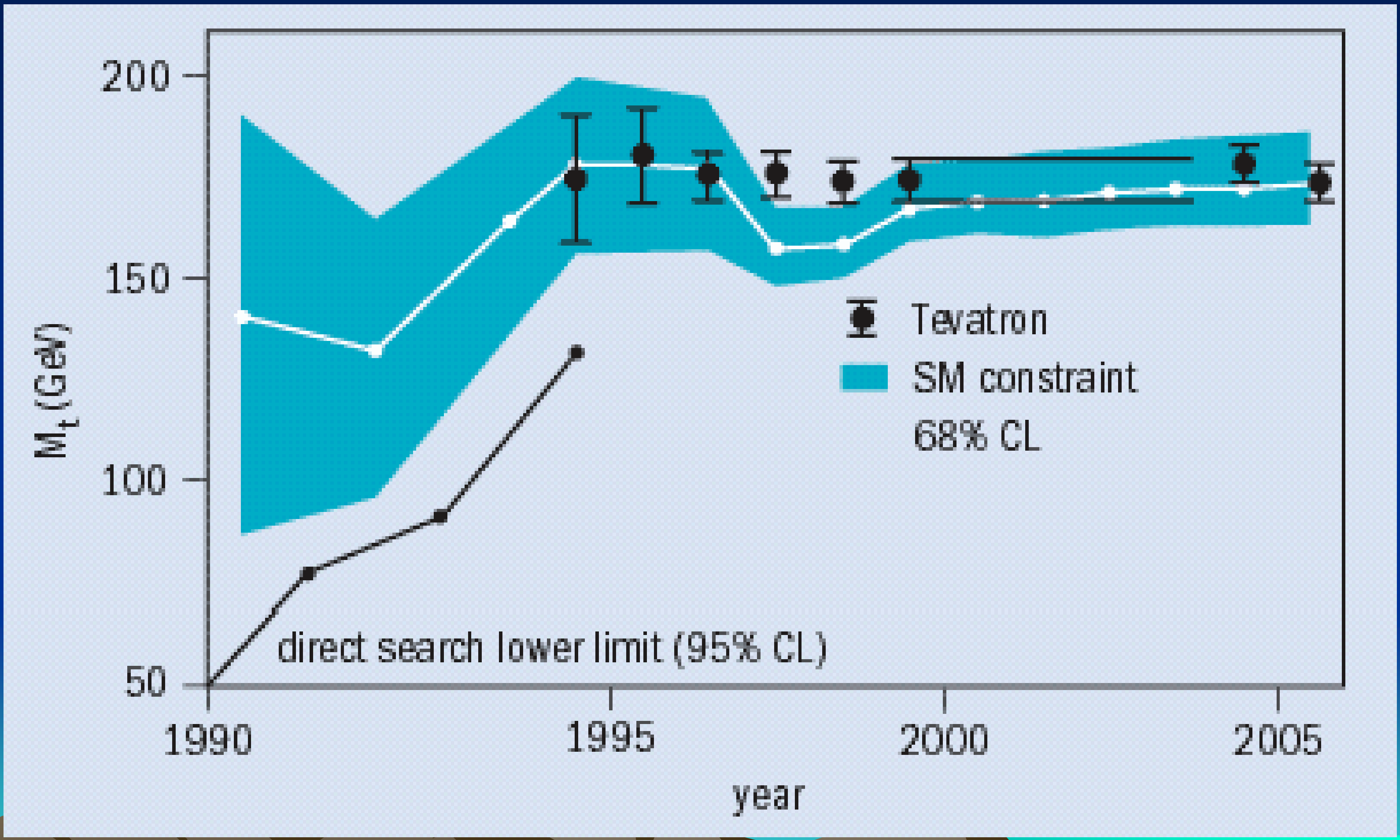


We also have a chance to understand this...

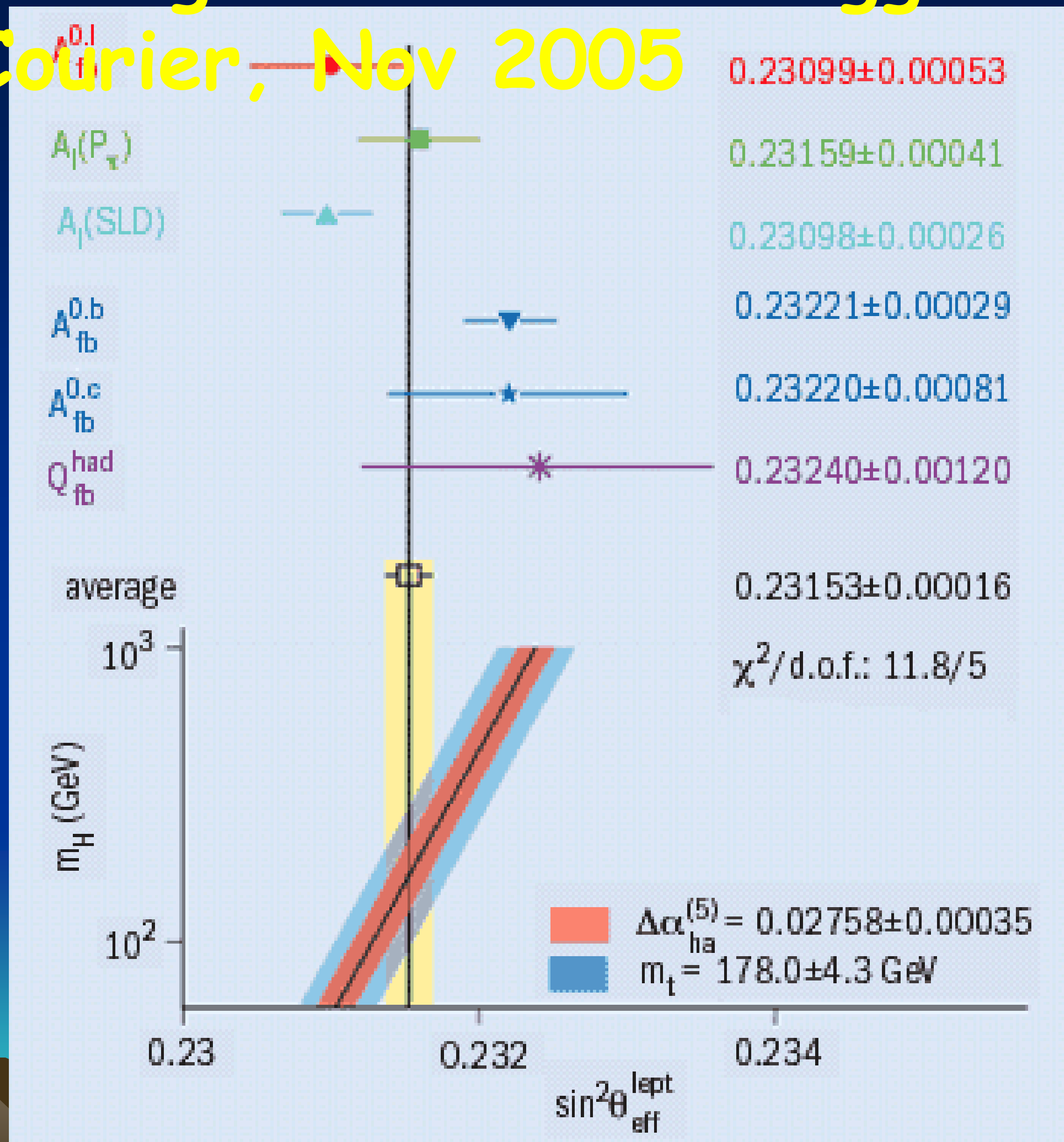
NB. Not only WMAP data going into this ΛCDM model, still

not bad!

Why do we think indirect, precision e+e- measurements will tell us anything??? CERN Courier, Nov 2005 :



Now, same game with the Higgs:
CERN Courier, Nov 2005



Recent electroweak combinations

(mainly e+e- + ppbar data):

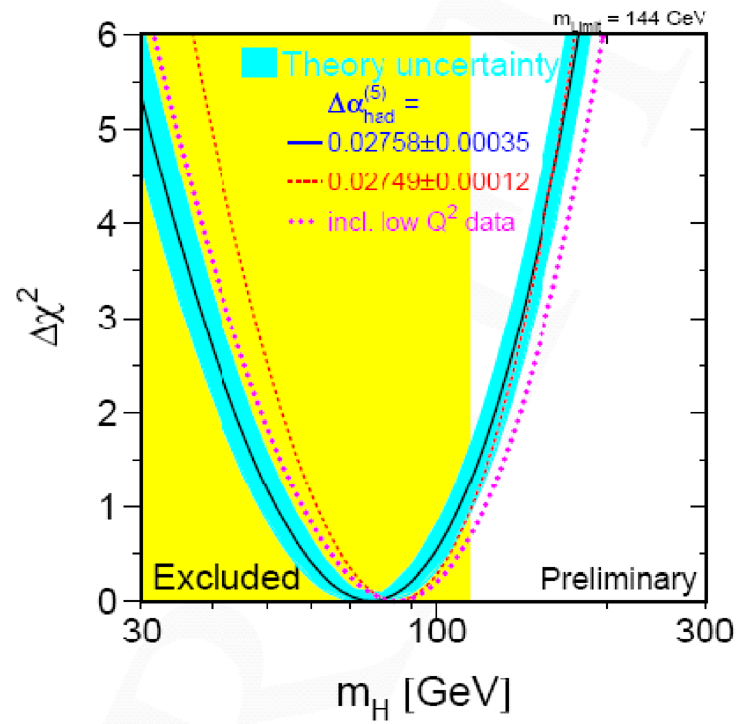
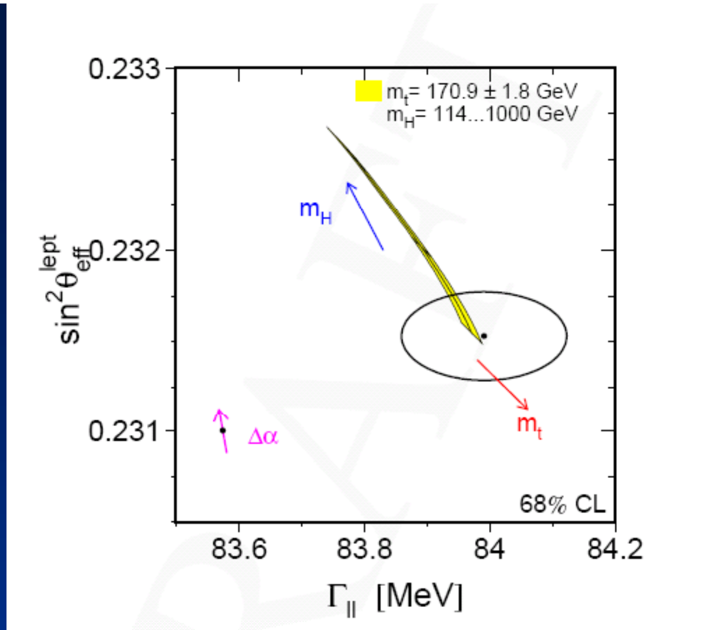
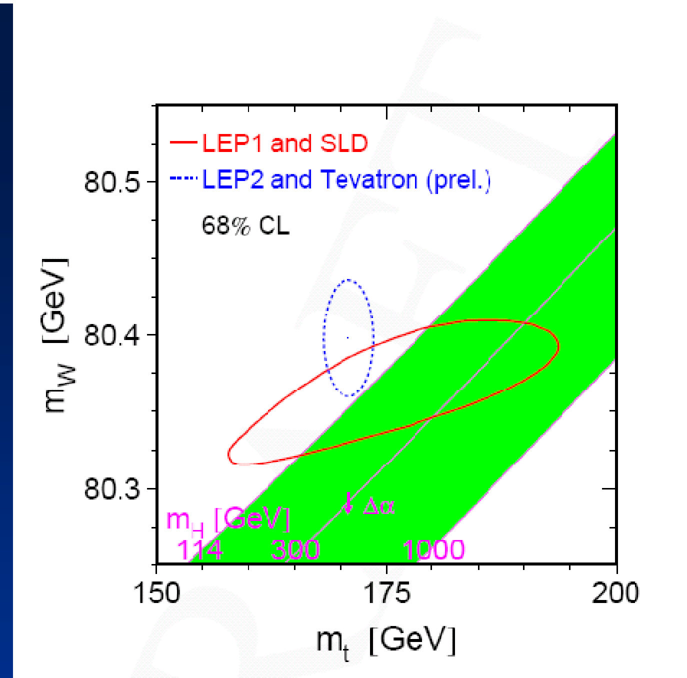
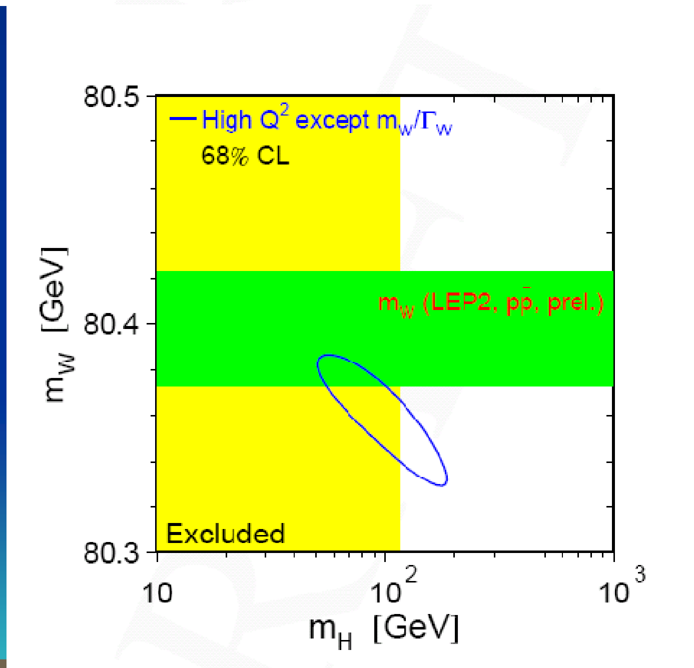
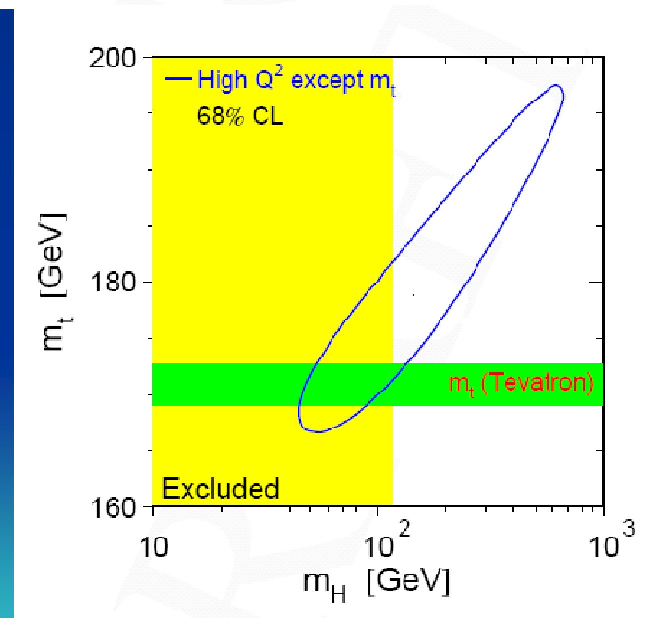


Figure 5: $\Delta\chi^2 = \chi^2 - \chi^2_{min}$ *vs.* m_H curve. The line is the result of the fit using all high-Q^2 data (last column of Table 2); the band represents an estimate of the theoretical error due to missing higher order corrections. The vertical band shows the 95% CL exclusion limit on m_H from the direct search. The dashed curve is the result obtained using the evaluation of $\Delta\alpha^{(5)}_{had}(m^2_Z)$ from Reference 62. The dotted curve is the result obatined including also the low-Q^2 data.

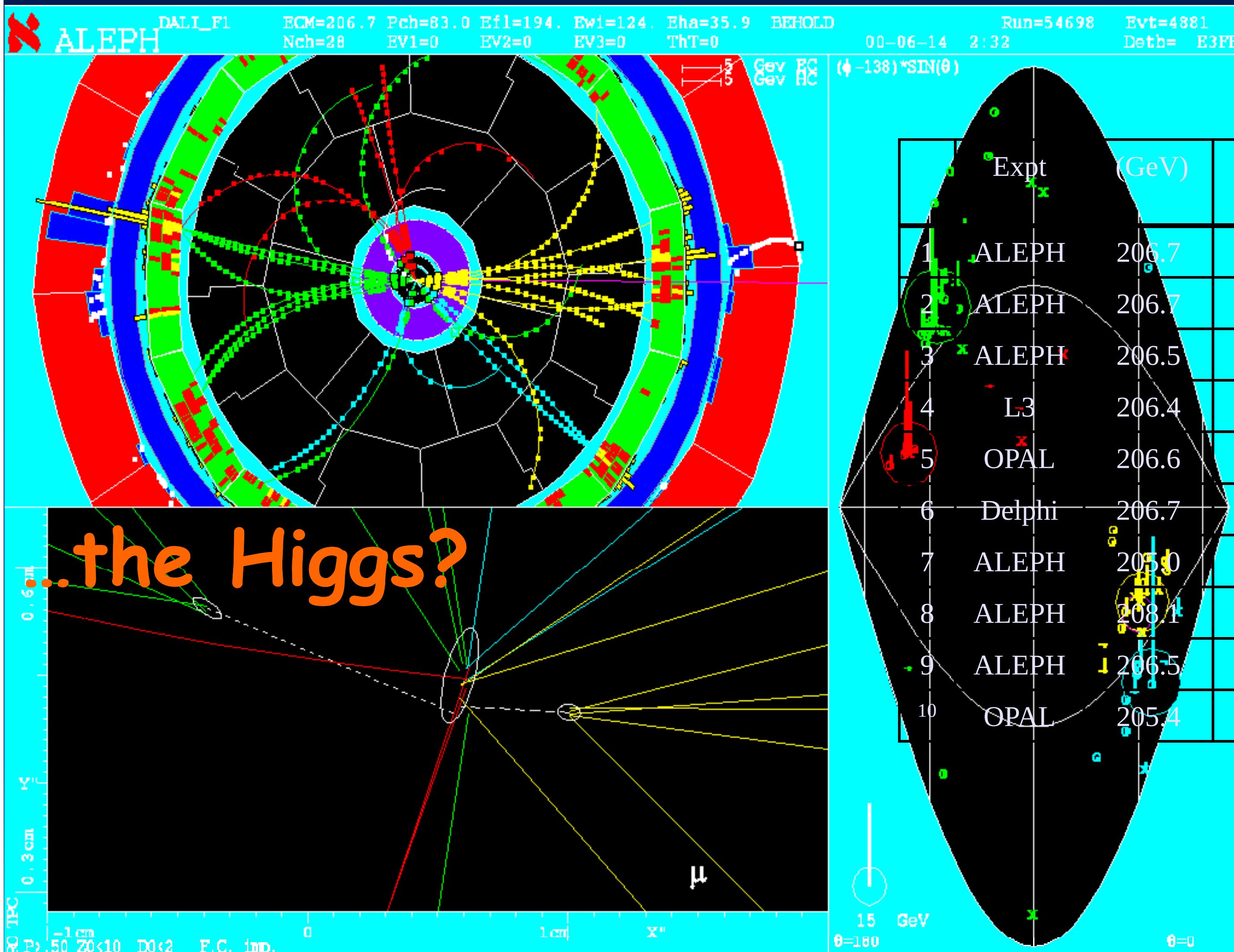

0.233
0.232
0.231
$\sin^2\theta_{eff}^{lept}$
m_t= 170.9 ± 1.8 GeV
m_H= 114...1000 GeV
m_H
m_t
$\Delta\alpha$
68% CL
83.6
83.8
84
84.2
Γ_{ll} [MeV]


LEP1 and SLD
LEP2 and Tevatron (prel.)
68% CL
80.5
80.4
80.3
m_W [GeV]
m_H [GeV]
114
300
1000
$\Delta\alpha$
150
175
200
m_t [GeV]


High Q^2 except m_W/Γ_W
68% CL
m_W (LEP2, $p\bar{p}$, prel.)
Excluded
80.5
80.4
80.3
m_W [GeV]
10
10^2
10^3
m_H [GeV]


High Q^2 except m_t
68% CL
m_t (Tevatron)
Excluded
200
180
160
m_t [GeV]
10
10^2
10^3
m_H [GeV]

And in addition we have LEP events…

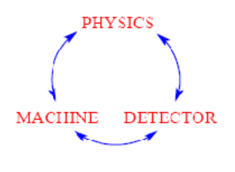


	Expt	(GeV)	Decay Channel	(GeV/c^2)	ln(1+s/b) 115 GeV/c^2
1	ALEPH	206.7	4-jet	114.3	1.73
2	ALEPH	206.7	4-jet	112.9	1.21
3	ALEPH	206.5	4-jet	110.0	0.64
4	L3	206.4	E-miss	115.0	0.53
5	OPAL	206.6	4-jet	110.7	0.53
6	Delphi	206.7	4-jet	114.3	0.49
7	ALEPH	205.0	Lept	118.1	0.47
8	ALEPH	208.1	Tau	115.4	0.41
9	ALEPH	206.5	4-jet	114.5	0.40
10	OPAL	205.4	4-jet	112.6	0.40

PRECISION @ILC…

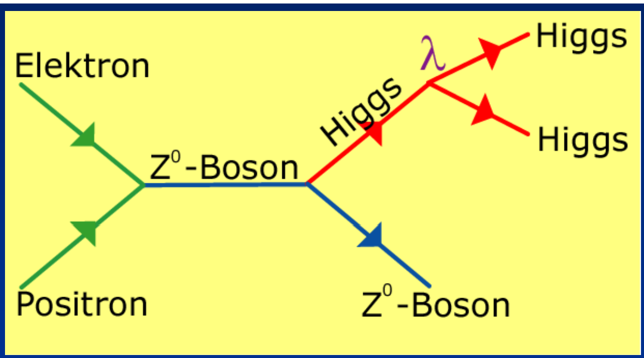
PHYSICS ⟷ MACHINE

Executive Summary



HIGGS

DISCOVERY & PRECISION MEAS. of
PRODUCTION, COUPLINGS



Need highest luminosity
Precision for 1 ab^{-1} :

$$\Delta\lambda/\lambda \cong 20\,\%$$

10^5 Higgs few % 20%

$\rightarrow$ 500 fb^{-1} @ $\sqrt{s} \sim m_Z + m_W + 25$ GeV
$\sim$ 230 GeV acc. to EW fits

TOP

PRECISION MEASUREMENT

Mass $\delta m_t \sim 100$ Mev

Z charges $\begin{matrix} v_t = 1 - \frac{8}{3} \cdot {s_W}^2 \\ a_t = +1 \end{matrix}$ $\sim 1\%$

Mag., El. dip. mom. $\sim 1\%$, $\sim 10^{-18}$

Yukawa Coupling $g^2_{ttH} \sim 5\%$

$\rightarrow$ 300 fb^{-1}, 1000 fb^{-1} @ 400 GeV, 700 GeV

polarized beams

WW

PRECISION MEAS.

Mag.dip., El.quad. mom.

$$\left.\begin{aligned} \mu_{\gamma,Z} &= -\frac{e}{M_W}[z + \delta\kappa_{\gamma,Z} + \lambda_{\gamma,Z}] \\ Q_{\gamma,Z} &= -\frac{e}{M_W^2}[1 + \delta\kappa_{\gamma,Z} + \lambda_{\gamma,Z}] \end{aligned}\right\} \delta\kappa, \delta\lambda \sim 10^{-3}$$

$\rightarrow$ few 100 fb^{-1} @ 500 GeV

polarized beams

SUSY

DISCOVERY & PRECISION MEAS.

Meas. all Susy parameters

$\rightarrow$ many 100 fb^{-1} up to highest energy

polarized beams

BEYOND E–W

PRECISION MEAS. & DISCOVERY

Z′, f*, H^{ns}, LQ, TC, $n_D > 4 \ldots$

$\rightarrow$ few 100 fb^{-1} up to highest energy

polarized beams

Z – PEAK

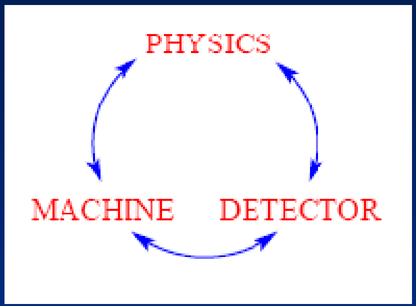
PRECISION MEAS.

$\delta \sin^2\theta_W \sim 10^{-5}, \delta M_W \sim 6$ MeV

$\rightarrow$ 1 Giga Z

polarized beams

"Loop corrections" and precision measurements make the ILC sensitive to physics way beyond the c.m. energy of the machine…



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e.g., $M_{Z'} \sim$ 5 TeV

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DISCOVERY

Susy – Alternative Theories

e.g., 'Susy Forest'

→ **NECESSARY** COMPLEMENT to LHC

Example of Experimental Programme

- ILC

$\sqrt{s} =$ 91 500 800/1000 GeV

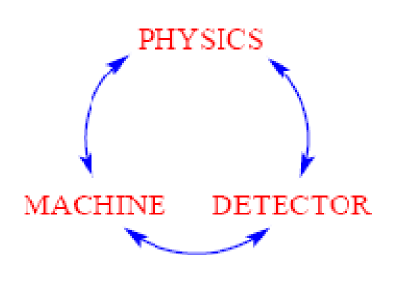
$\mathcal{L} = 6 \times 10^{33}$ 3×10^{34} 5×10^{34} $cm^2 s^{-1}$

- PHYSICS

Year	Physics	$\sqrt{s}$ Gev	$\int \mathcal{L}dt$ fb^{-1}	Years Runnin
2019	Commissioning			1
2020	Higgs	250	200	2
2022	Top	350	200	1
2025	WW, HHH	500	500	2
2028	Susy			
+y	Yukawa ttH	750	1000	2
+NP=10	New Physics			
y	GZ	91	50	1
	M_W	161	100	1

$\Sigma \sim$ **25**

Now to the detector. We want:



Physics → Detector Goals

- vertexing — $\delta(\mathrm{IP}_{\phi,z}) \lesssim 5\mu\mathrm{m} \oplus \frac{10\mu\mathrm{m\,GeV}/c}{\mathrm{p}\sin^{3/2}\theta}$
  e.g. $t\bar{t}$
- tracking — $\delta(1/\mathrm{p_t}) \lesssim$ Now 2x10-5/(GeV/c)
  e.g. Higgs
- fwd. dirn — $\delta(1/\mathrm{p_t}) \lesssim 3 \times 10^{4}\mathrm{GeV}/c^{-1}$,
  e.g. lumi, t–ch.phys. — $\delta(\theta) \lesssim 2 \times 10^{-5}, \cos\theta \lesssim 0.99$
- jet energy — $\delta(E/E) \lesssim$ Now 0.25/√E @ Zpeak
  from Particle Flow
- hermeticity — $\sim$ 5 – 10 mrad for beampipe,
  for $\not{E}$ meas. — only hole
- backgrounds — min. material inside Ecal,
  robustness — $\vec{B} \gtrsim$ 3T, granularity

R & D, prototyping to shoot for these goals

Andrei Seryi at IRENG07 : Detector - machine interfaces

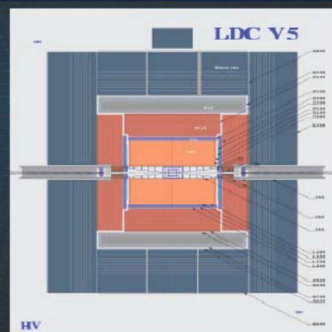
- The two complementary detectors for ILC IR may have different design, sizes, etc.
- Differences of their interfaces to the machine should be understood, and if possible, unified

Borrowed from Henri Videau at a CLIC workshop; we are discussing with them about the detector (ILC has done a lot of work on the detector)…

LDC

A large detector with
1.6 m tracker radius and 4T
12.4m x 12m

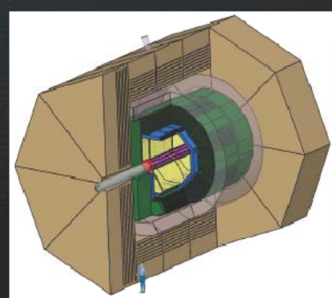
A TPC for tracker



with an eight-fold symmetry in ϕ

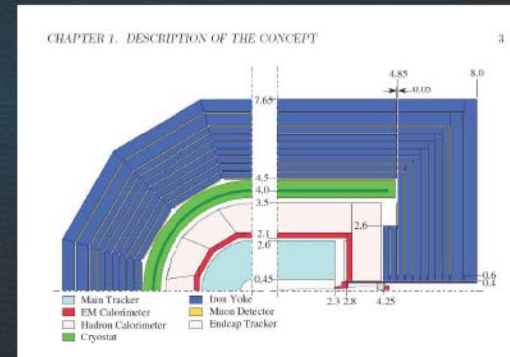
A highly granular W-Si 25 mm² 80M ch
electro-magnetic calorimeter
and hadronic calorimeter read
analogically 9cm² or digitally 1cm²
in iron or brass

A HCAL in the very forward



Henri Videau LLR–École polytechnique CLIC 2007 CERN, October 2007

GLD



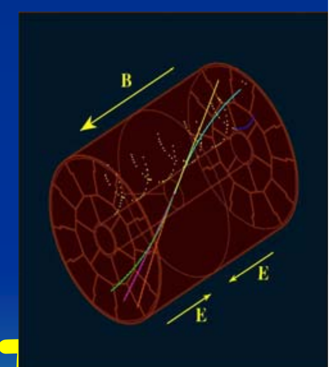
The largest detector with a 2m tracker radius and a 3T field
16m x 15.3m

The innermost detectors are similar in the different concepts
but for the inner radius of the Vdet dictated by the field

A TPC for tracker

A large yoke to provide an adequate B field in the TPC
and a small stray field at the level of the quads.
A granular calorimetry in scintillator by fear of the silicon cost
fo[r su]ch a size W then Pb for 5.7 λ

Henri V[ideau] LLR–École polytechnique CLIC 2007 CERN, October 2007



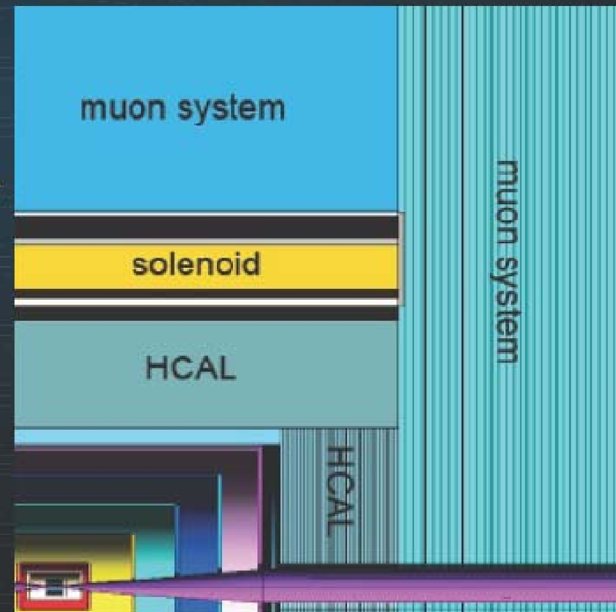
Joined to 'ILD' for LOI

SiD

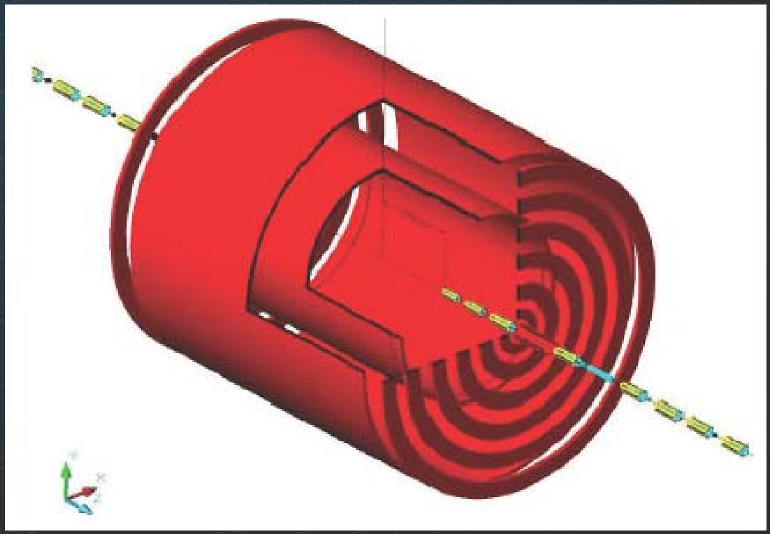
a detector of equivalent global size
tracker radius 126.5 cm and 5 T
11.8m x 12.9m

A full silicon tracker
providing 5 precise points

A highly granular W-Si 12 mm²
electro-magnetic calorimeter
and hadronic gas calorimeter read
digitally in iron



4th concept

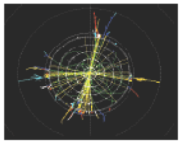


A 3.5 T inner field
in a -1.5T outer field
with coil walls
14m x 12m

An inner part like the others
with a TPC (R=1.4m) for tracker

Calorimetry: a crystal component for ECAL, a triple readout fiber system for HCAL for computing the compensation.

Now we shall take a look at the subdetectors…



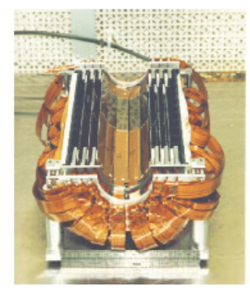
Inner Tracking/Vertex Detection for the ILC

Detector Requirements

- Superb impact parameter resolution (**$5\mu m \oplus 10\mu m/(p \sin^{3/2}\theta)$**)
- Excellent spacepoint precision (**< 4 microns**)
- Transparency **(~0.1% X_0 per layer**)
- Track reconstruction (**find tracks in VXD alone**)
  - Requires good angular coverage with several layers close to IP
- Sensitive to acceptable number of bunch crossings (**<150 BX = 45 μsec**)
- Electromagnetic interference (EMI) immunity
- Power Constraint (**< 100 Watts**) - to achieve optimal transparency

Concepts under Development for International Linear Collider

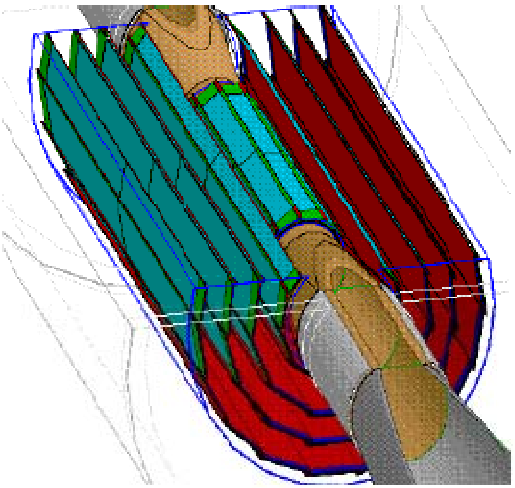
- Charge-Coupled Devices (CCDs)
  - demonstrated in large system (307Mpx) at SLD, but slow ⇒ Column Parallel CCDs, FPCCD
- Monolithic Active Pixels – CMOS
  - MAPs, FAPs, Chronopixels, 3D-Fermilab
- DEpleted P-channel Field Effect Transistor (DEPFET)
- Silicon on Insulator (SoI)
- Image Sensor with In-Situ Storage (ISIS)
- HAPS (Hybrid Pixel Sensors)

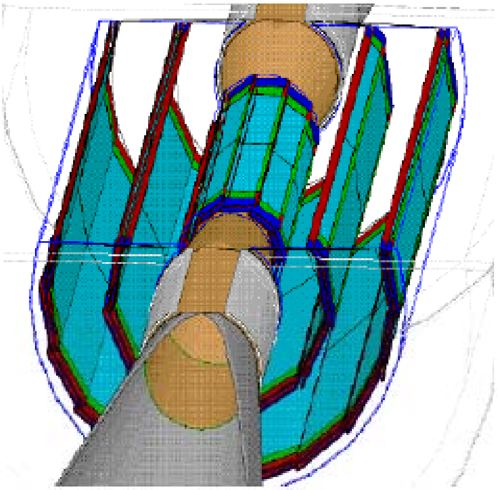


Jim Brau　**ILC Detector Development**　Terascale Helmholtz Alliance Workshop, Dec 5 , 2007　22

Improved VTX (D. Grandjean)

- Two new drivers
- LDC-like geometry and GLD-like geometry
- Flexible for VTX optimisation studies
- Models driven by VTX community (a very positive move)





Comments/Questions:

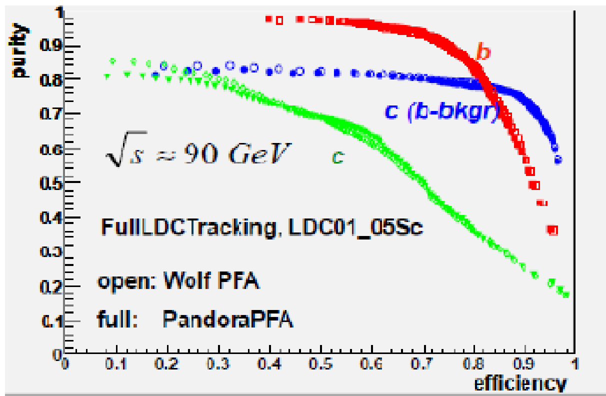
- Mass generation with LDC-like geometry
- NOT yet validated with tracking/LCFI Vertex reconstruction code !
  - but being studied (Lynch) – report at next optimisation meeting
- Fallback solution – revert to old model…

ILD Meeting, Sendai, 7/3/2008 Mark Thomson

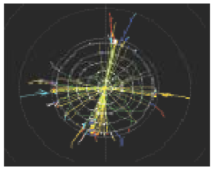
LCFI Vertex Package

Sonia Hillert

- LCFI Vertex is the standard vertexing package.
- Consistent performance with Pandora PFA and WOlfPFA



Need a training of neural network to apply to the flavor tagging.
Now preparing for trainings using mass production data



Central Tracking

- Two general approaches being developed for the ILC

  TPC

  - Builds on successful experience of PEP-4, ALEPH, ALICE, DELPHI, STAR, ...
  - Large number of space points, making reconstruction straight-forward
  - dE/dx ⇒ particle ID, bonus
  - Minimal material (endplate), important for calorimetry
  - Tracking up to large radii

  Silicon

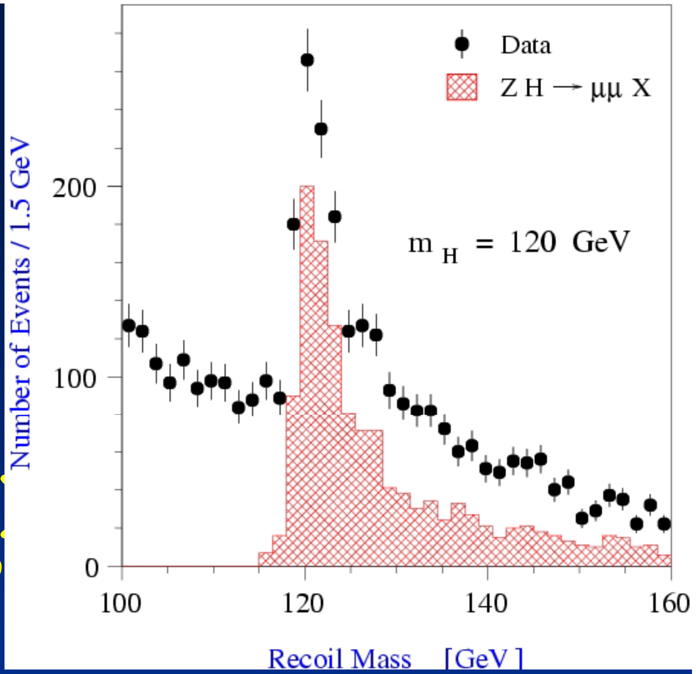
  - Superb spacepoint precision allows tracking measurement goals to be achieved in a compact tracking volume
  - Robust to spurious, intermittent backgrounds
    - ILC is not a storage ring

Physics determines detector design

★ **momentum: d(1/p) ~.9x10^{-4}/GeV (TPC only)**

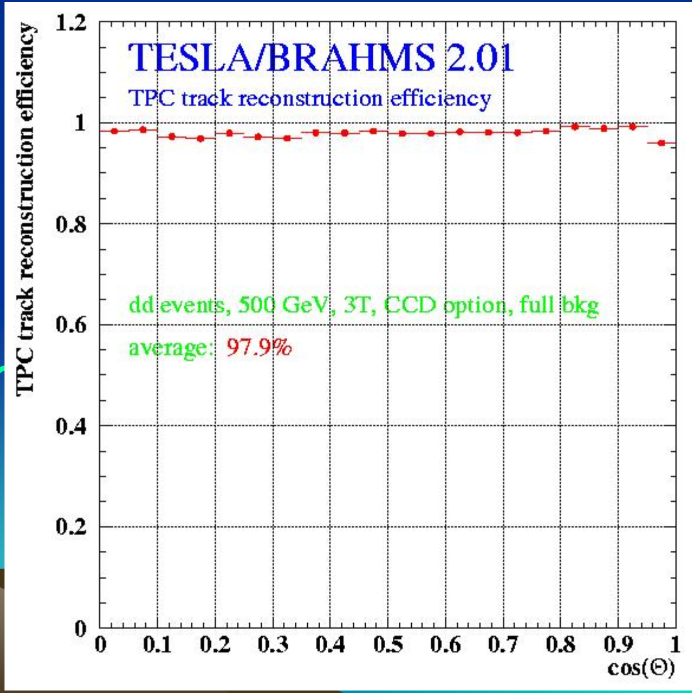
~ .3x10^{-4}/GeV(w/IP) (1/10xLEP)

$e^+e^- \rightarrow ZH \rightarrow ll\ X$ goal: $\delta M \sim 20$MeV



★ **tracking efficiency: 98% (overall)**

excellent and robust tracking efficiency by combining vertex detector and TPC, each with excellent tracking efficiency



Calorimeters

A detector designed for P-flow

Particle Flow stresses:

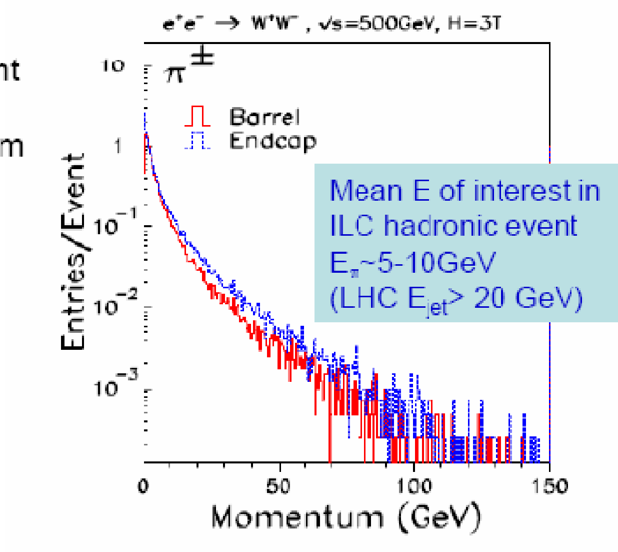
- reconstruction of each particle in an event
- separation of particles
- replacement of E with tracking momentum

Less important:

- single particle energy resolution in calo.

Detector requirements:

- good tracking, in particular in dense jets
- excellent granularity in the ECAL
- good granularity in the HCAL
- excellent matching between tracker / ECAL / HCAL



the E of interest does not increase linearly with ⌧s but the multiplicity of particles does!

E. Garuti CLIC workshop - CERN, 16-18 October 2007 5

Optimization of the calorimeter

Sandwich structure chosen for ECAL and HCAL

Absorber material and readout granularity

→ separation of individual particles from E_{vis}

compact showers: small X_0 and $r_{Moliere}$

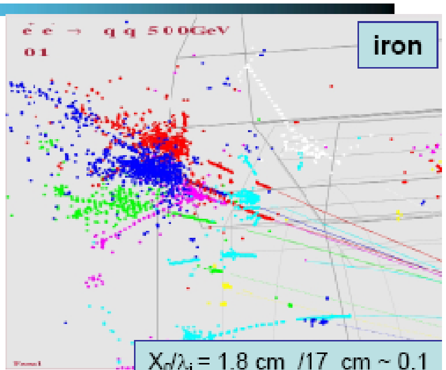
high lateral granularity: $r^2_{cell} \sim r^2_{Molier}$

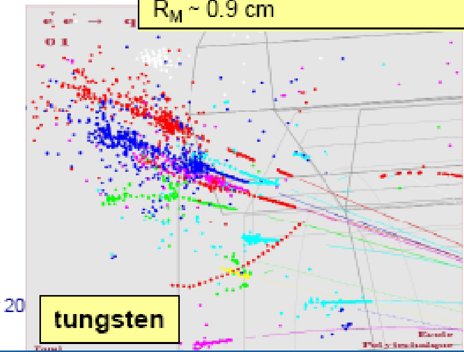
→ discrimination between em / hadronic showers

different longitudinal scale: small X_0/λ_{had}

high longitudinal segmentation

→ containment of EM showers in ECAL





Hardware or software compensation

→ high granularity allows separation of em / hadronic components of shower

→ hardware compensation not mandatory

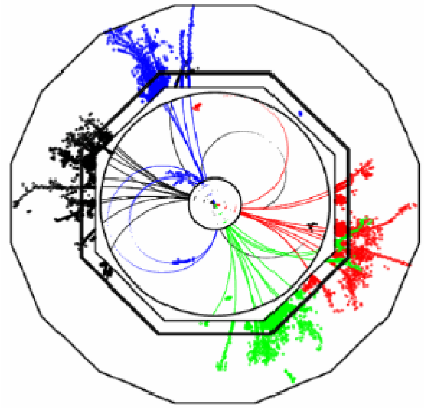
ILC: W-ECAL + Fe-HCAL

CLIC: W-ECAL + W-HCAL ?

E. Garutti CLIC workshop - CERN, 16-18 October 20

P-flow performance today

from Mark Thompson, CALICE-UK, Cambridge



several algorithms are being developed
today best performing:
PandoraPFA (M. Thompson)

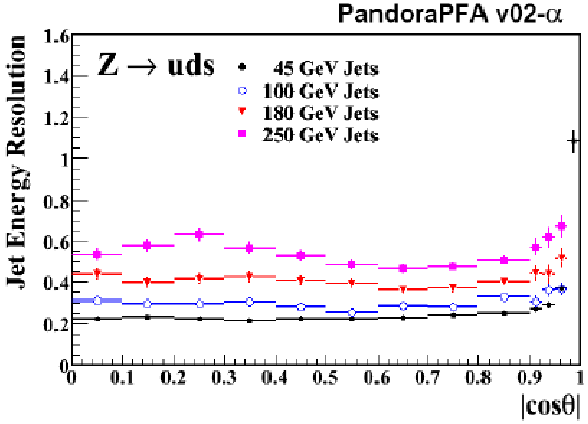
PandoraPFA v02-α

E_{JET}	$\sigma_E/E = \alpha/\sqrt{E_{jj}}$ $\lvert\cos\theta\rvert<0.7$	σ_E/E_j
45 GeV	0.227	3.4 %
100 GeV	0.287	2.9 %
180 GeV	0.395	2.9 %
250 GeV	0.532	3.4 %

★ **For 45 GeV jets, performance now equivalent to**

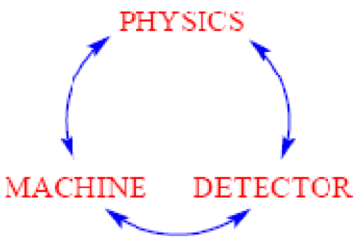
23 % / √E

energy range > 100 GeV still problematic
but … work in progress !



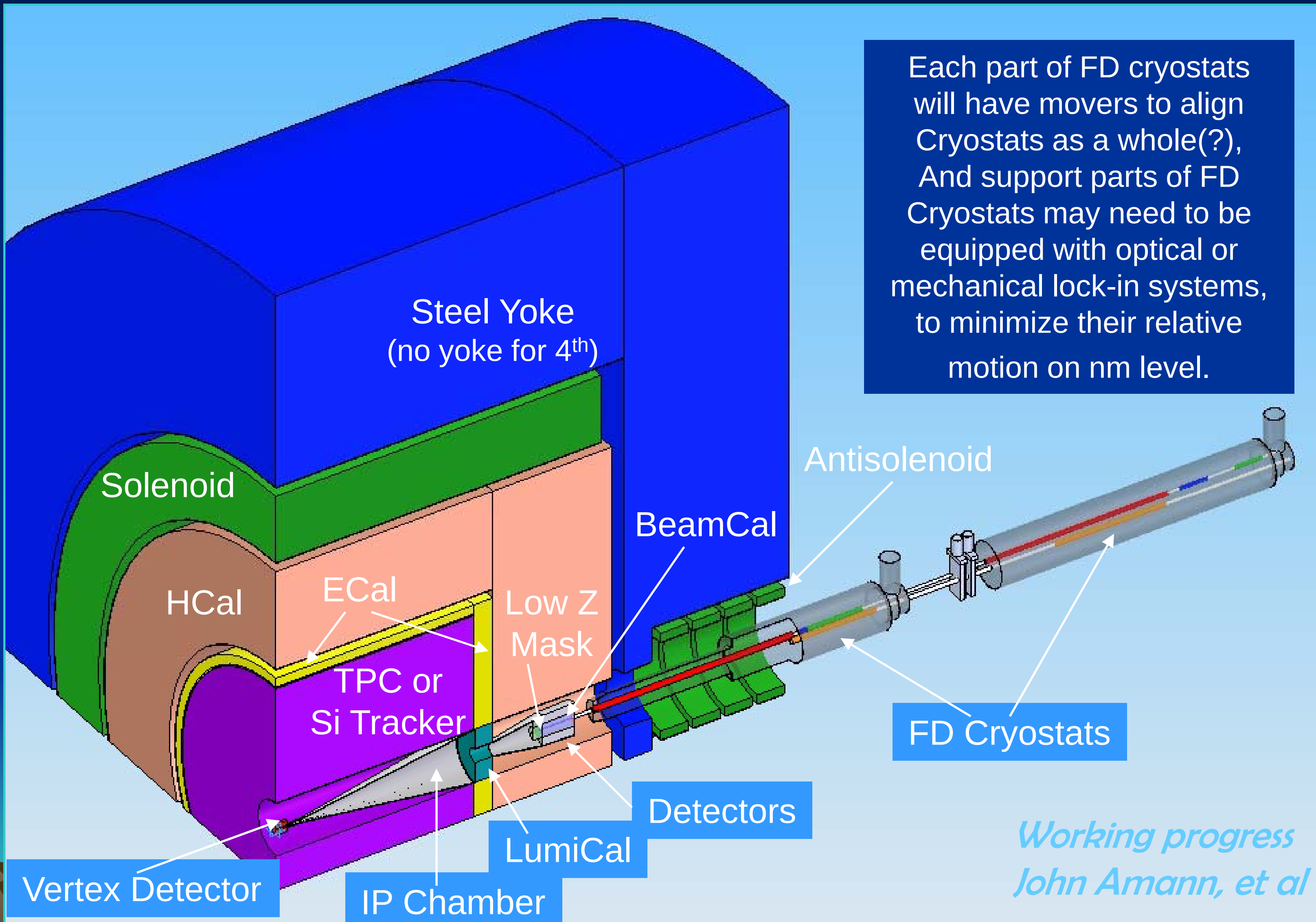
09/2007

For CLIC: separation of particles within a jet difficult due to high density
P-flow can work for separations of jets

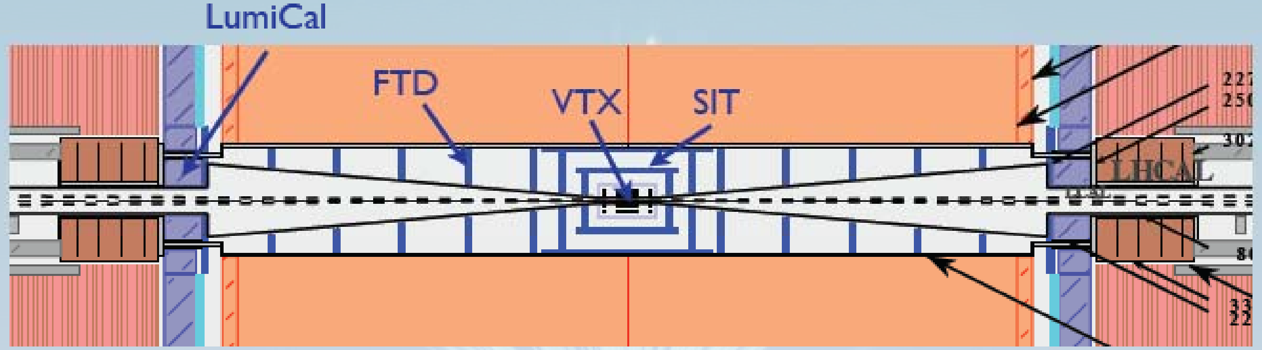


Inner Detectors → back to Machine since this is complicated real-estate where MDI, machine and detector elements are critical…

Each part of FD cryostats will have movers to align Cryostats as a whole(?), And support parts of FD Cryostats may need to be equipped with optical or mechanical lock-in systems, to minimize their relative motion on nm level.

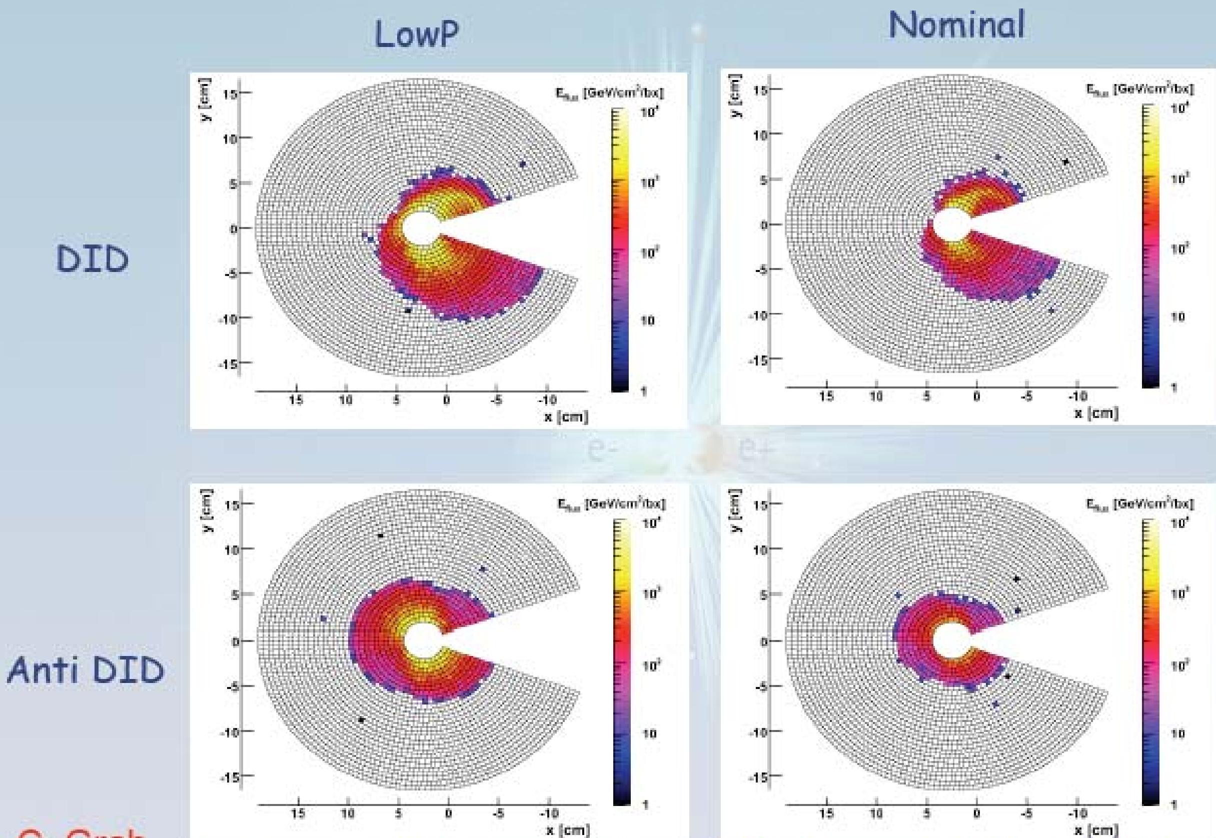


LDC Interaction Region



- Vertex Detector VTX
- Intermediate Silicon tracking SIT, FTD
- Beam pipe design which minimises the amount of material in front of the LumiCal (Bhabha scattering)

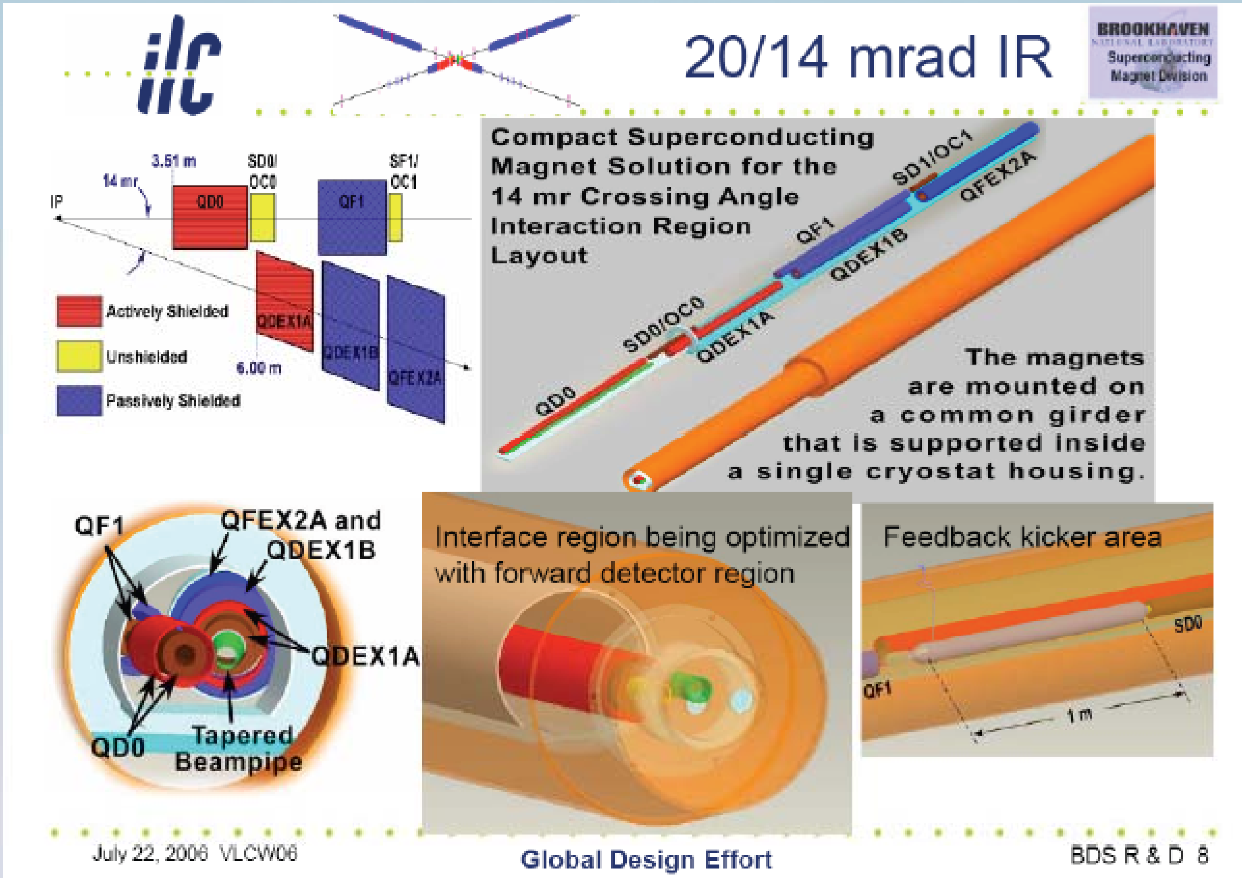
Beamstrahlung Pairs on the BeamCal



C. Grah

Larger blind area compared to 20 mrad (30° => 40°)

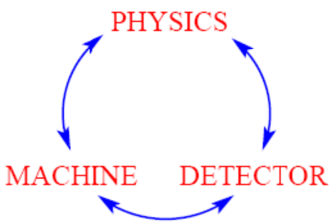
14 mrad Crossing Angle



Combination of detector and machine elements."Detector view of MDI"? Nanobeam02 paper…

Abstract

The jobs at hand concern everybody in the LC business. Establishing and controlling the e^+e^- luminosity at a level



of $10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$ in the interaction region (IR), i.e., from the final quadrupoles to the interaction point (IP), will require a sophisicated interplay of several technologies dealing with gymnastics on nanometer-sized colliding beams. An overview of the issues is given in this contribution to Session[4] of the Nanobeam Workshop[1]-[9].

1 INTRODUCTION

One way to break down the tasks at the IR is to categorize them according to: **V**ibration, beam **O**ptics, **I**nstrumentation, **B**ackgrounds/masking and **E**ngineering, as illustrated in Fig.1. The tasks are highly correlated as evidenced by the repetition in the descriptions below.

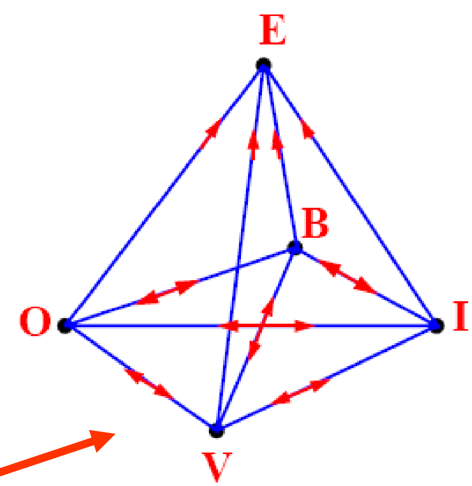


Figure 1:

A detailed account of the LC technological status, including topics in this paper, has been prepared by the International Linear Collider Technical Review Committee (ILCTRC) chaired by Greg Loew[8].

Many very correlated tasks!!

In preparing this talk, I noticed the differend ways to categorize…

Nanobeam 02 paper:

vibration,
optics,
instrumentatn,
background,
engineering

Karsten Buesser CLIC talk:

- Usually the following things are discussed under the MDI label:
  - Interaction Region Design (crossing angles, magnets, etc.)
  - Detector Forward Regions
  - Beam-induced Backgrounds
  - Diagnostics (Luminosity, Energy, Polarisation)
  - Detector Hall Design
  - Engineering Issues: e.g. Push-pull

Andrei Seryi IRENG07:

ilc IRENG07 Working Groups

- WG-A: Overall detector design, assembly, detector moving, shielding.
  - Including detector design for on-surface assembly and underground assembly procedures. Beamline pacman & detector shielding…
    - Conveners: Alain Herve (CERN), Tom Markiewicz (SLAC), Tomoyuki Sanuki (Tohoku Univ.), Yasuhiro Sugimoto (KEK)
- WG-B: IR magnets design and cryogenics system design.
  - Including cryo system, IR magnet engineering design, support, integration with IR, masks, Lumi & Beamcals, IR vacuum chamber…
    - Conveners: Brett Parker (BNL), John Weisend (SLAC/NSF), Kiyosumi Tsuchiya (KEK)
- WG-C: Conventional construction of IR hall and external systems.
  - Including lifting equipment, electronics hut, cabling plant, services, shafts, caverns, movable shielding; solutions to meet alignment tolerances…
    - Conveners: Vic Kuchler (FNAL), Atsushi Enomoto (KEK), John Osborne (CERN)
- WG-D: Accelerator and particle physics requirements.
  - Including collimation, shielding, RF, background, vibration and stability and other accelerator & detector physics requirements…
    - Conveners: Deepa Angal-Kalinin (STFC), Nikolai Mokhov (FNAL), Mike Sullivan (SLAC), Hitoshi Yamamoto (Tohoku Univ.)

A.Seryi, IRENG07 Goals and Introduction 3

Yasuhiro Sugimoto, Toshiaki Tauchi, Karsten Buesser et al ILD MDI/Integration list:

1. IR issues/tasks
2. Detector Integration taskd
3. Push-pull issues/tasks

Many subitems under each point, as you can see next→

List of Issues/Tasks for ILD MDI/Integration

1. IR Issues/Tasks

1.1 IR design optimization with engineering studies

- beam pipes, pumps, wakefields
- innermost radius of VTX and B-field
- outer radius of support tube and inner radius of TPC
- calorimeters, pair monitor and beam instrument

1.2 Background estimation

- pairs v.s. B-field, (anti-)DID
- muons v.s. muon spoilers, collimation depth
- synchrotron radiations v.s. collimation depth, masks
- neutrons from pairs, extraction line and dump v.s. mask

1.3 Relevant parameters for IR optimization

The relevant parameters are listed in a following table, where differences will be studied and tried to be understood.

	GLD and GLDc		LDC
machine parameter set	1TeV, HiLum-1		nominal?
L* (m)	4.5	same in GLDc	4.05
B (Tesla)	3	3.5 in GLDc	4
R_{Be} (cm)	1.5	z < 5cm	1.4
R_{VTX} (cm)	2.0	FPCCD	1.6
VTX angular acceptance	|cos|<0.95	3 super-layers	|cos|<0.952
R_{FCAL} (cm)	8	z = 2.3m	8
R_{BCAL} (cm)	1 and 1.8	z = 4.3m	1.3
support tube	cantilever 70cm dia.	10cm^3 W-tube	cantilever 58cm dia.

Common parameters have been suggested by the detector optimization working group as listed below.

Detector concept			GLD	LDC	GLD'	LDC'
TPC		R_{in} (m)	0.45	0.3	0.45	0.3
		R_{out} (m)	2.0	1.58	1.8	1.8
		Z_{max} (m)*	2.5	2.16	2.35	2.35
Barrel	ECAL	R_{in} (m)**	2.1	1.6	1.85	1.82
		Material	Sci/W	Si-W	Sci/W	Si-W
	HCAL	Material	Sci/W	Sci/Fe	Sci/W	Sci/Fe
Endcap	ECAL	Z_{min} (m)***	2.8	2.3	2.55	2.55
B-field (T)			3	4	3.5	3.5
VTX		inner layer (mm)	20	16	18	18

* GLD Z_{max} = 2.3 + 0.2m for TPC readout which has been included in LDC.
** LDC has less radial space between TPC and ECAL.
*** Fixed ECAL Z_{min} is proposed for well-defined TPC endplate region.

1.4 Beam pipe design

1. Vertex chamber
   B-field, pair background, collimation depth (synchrotron radiation profile at IP) a
   with BCAL as mask
2. In front of FCAL
   Precise luminosity measurement with ;
   - Beryllium or Aluminum straight pipe
     smearing effect to be studied
   - Right angular SUS pipe
     wake-field and minimum thickness for mechanical strength
3. Pump
   Background should be studied including electro-hadronic production in addition
   bremmstrahlung process between beam and residual gas.
   - P > 10nTorr for no baking, no pump
   - P > 1nTorr for no baking with NEG pumps

1.5 Outer radius of support tube

1. QD0 and SD0
   - compact superconducting magnets (B.Parker's design, 39cm dia.)
   - compact permanent magnets (Y.Iwashita's design)
   - anti-solenoid
     installed in the same cryostat by B.Parker's design
   - support structure with fine adjustment
     dynamic range of ±1mm and nanometer accuracy?
2. Thickness of tungsten tube
   - minimum value for backgrounds in endcap CAL and Muon chambers
   - CFRP tube which has less Young's modulus than tungsten
   - Mechanical strength for supporting QD0,FCAL,BCAL and LHCAL
3. Tracking in intermediate trackers between TPC and VTX
   - 4 layers for self-tracking capability in GLD
   - 2 layers for linkage in LDC

2. Detector Integration Issues/Tasks

2.1 Detector and its assembly on surface

- CMS-style assembly
  - coil support in the central ring, where the barrel part is divided i
  - mechanical strength
  - B-field uniformity and leakage field

2.2 Iron structure

- deformation due to B-field
  thickness of iron yoke : 2.7, 2.8 and 2.15m for GLD, GLDc and LDC
- global shape : dodeca-, dodeca- and octa-gon for GLD, GLDc and LDC
- field uniformity and leakage magnetic field
  tolerances ?
- split of end-Yoke ?

2.3 Solenoid and cryostat design

- feasibility of (anti-)DID in terms of engineering, cryogenics and B-field u
- how to wind coils and where ?

2.4 How to support inner detectors and QD0

- mechanical feasibility of cantilever system
- diameter of endcap hole

2.5 Opening, closing procedures

- requirement of experimental hall size and crane capacity
  GLDc : 31m x 120m x 33m (height) and crane of 100 tonnes
  Crane size largely affects the size of experimental hall.
- max 6m for detector endcap door opening in GLDc

2.6 Underground hall requirements

- where to put electronic trailers, need for service caverns
- temperature, humidity stability, the gradient
- utility (power, cooling water, gases, cables etc.)
- safety for fire, earth quake

3. Push-Pull Issues/Tasks

3.1 Re-commissioning machine operation

Re-commissioning process has been identified by T. Okugi (KEK) as listed bel

1. initial alignment less than 1mm (long, 3 mm)
2. Beam Based Alignment (BBA) of QD0 relative to upstream beam line
3. IP position scan for collision between 2 beams
   the major task and the most time consuming item !
4. Luminosity scan by changing SD0 transverse position
5. beam size tuning by sextupole (SD0, SF1) -knob

He suggested movers each for QD0,SD0 as well as QF1,SF1 .

3.2 Alignment of VTX and QD0

1mm displacement could happen. Is it tolerable ?
Or, fine adjustment system is needed in VTX ?

3.3 Slow settlement (100μm/month is tolerable ?)

Is it tolerable ?

3.4 Radiation, shielding around beam line

We could ask experts, e.g. T. Sanami (KEK), for estimation of self-shielding p

3.5 Cryogenics system for solenoid, QD0

What, how and where ?

3.6 Commissioning during assembling/survicing detectors

stability, safety in the interference

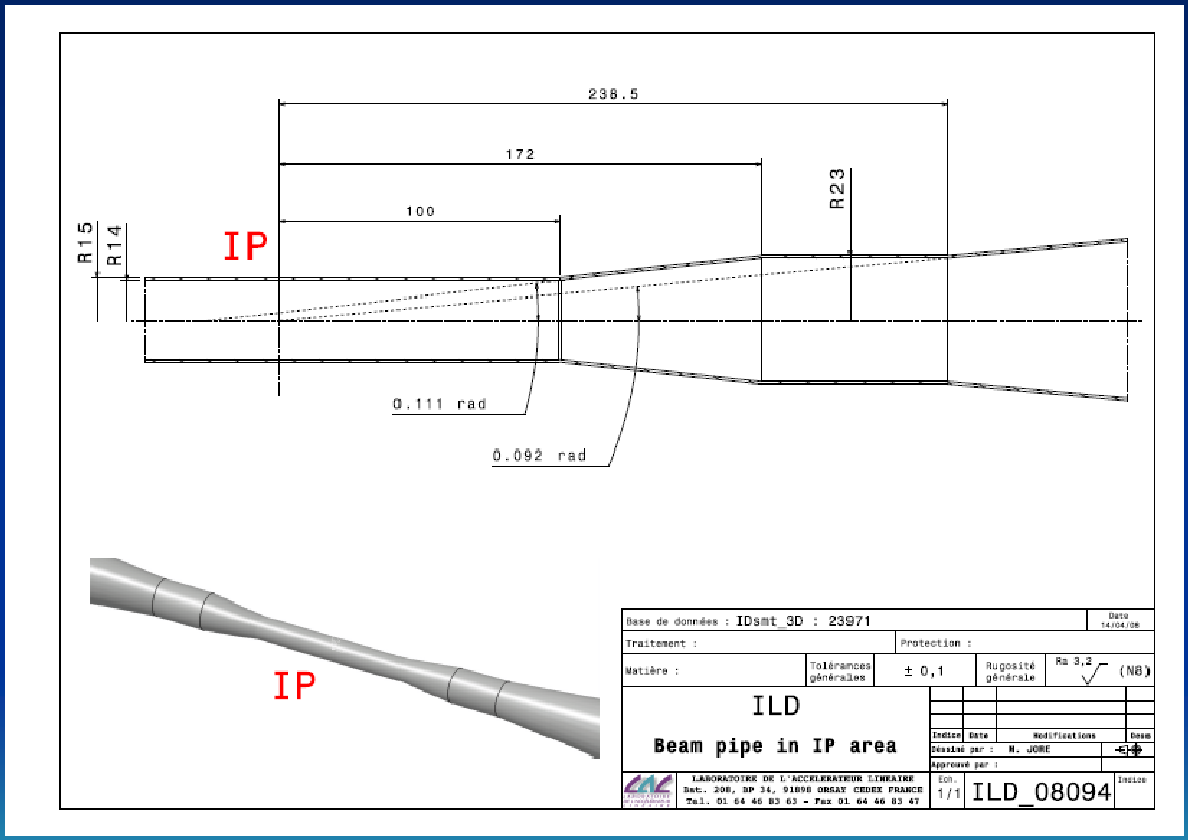
3.7 "Large" platform scheme

H. Yamamoto suggested it in terms of stability and reproducibility.

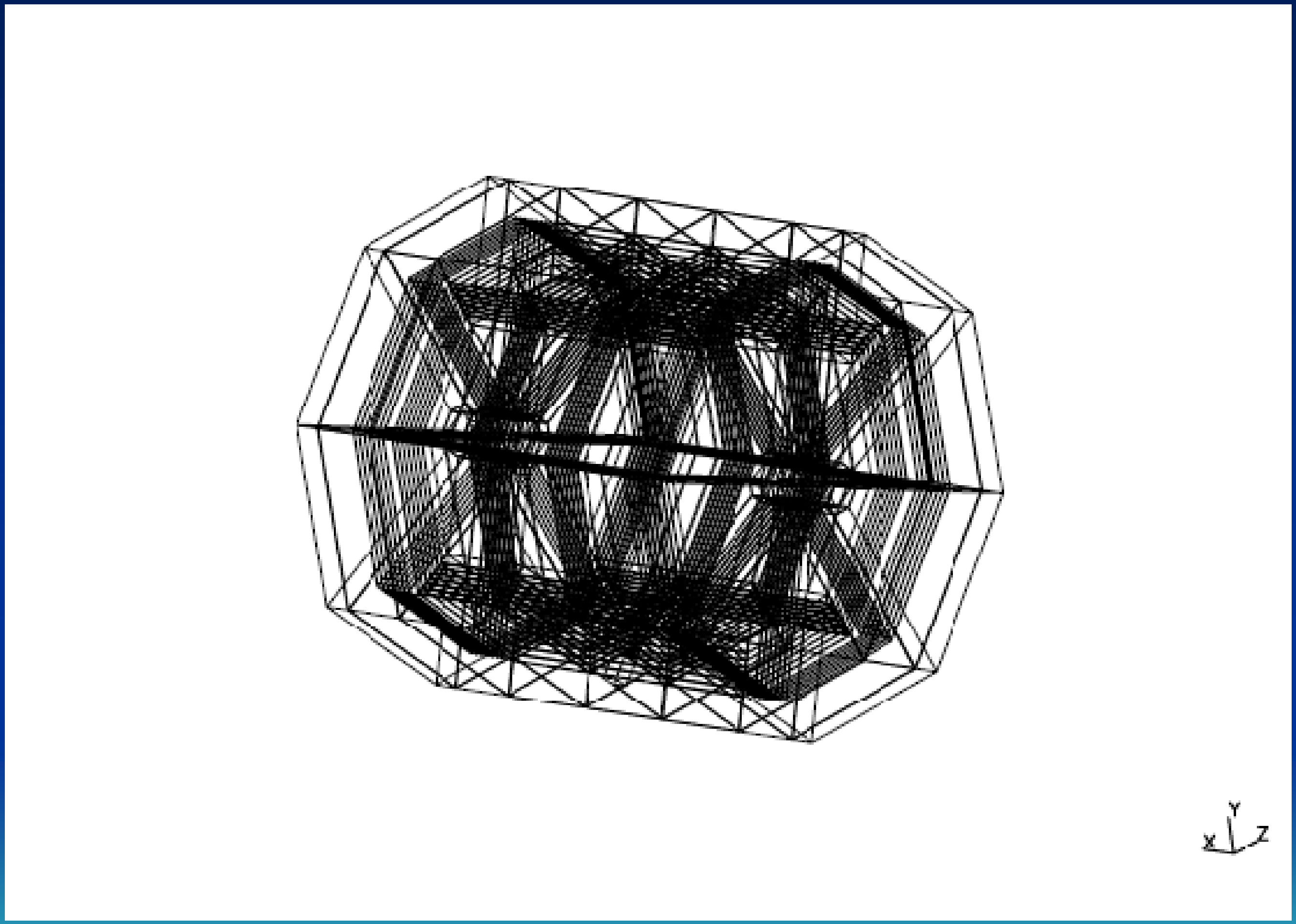
Combining MDI/Integration makes a lot of sense, as the IRENG07 workshop, the ILD task list and Andrei's/Toshiaki's lists today show, maybe something like:

- Vibration—det-hall design to avoid unwanted (µm-mm!) vibrations
- Optics—machine, BDS design/layout (details in Andrei's talk today)
- Instrumentation/diagnostics—fast feedback,beamcal e.g.
- Background—beam induced bgrd,inner detector design
- Engineering—
  - Detector design/integration
  - MDI magnets (antiDID)
  - IR hall/push-pull design (Andrei's talk today)
  - Shielding
  - Etc…

Some final examples of MDI/Integration…



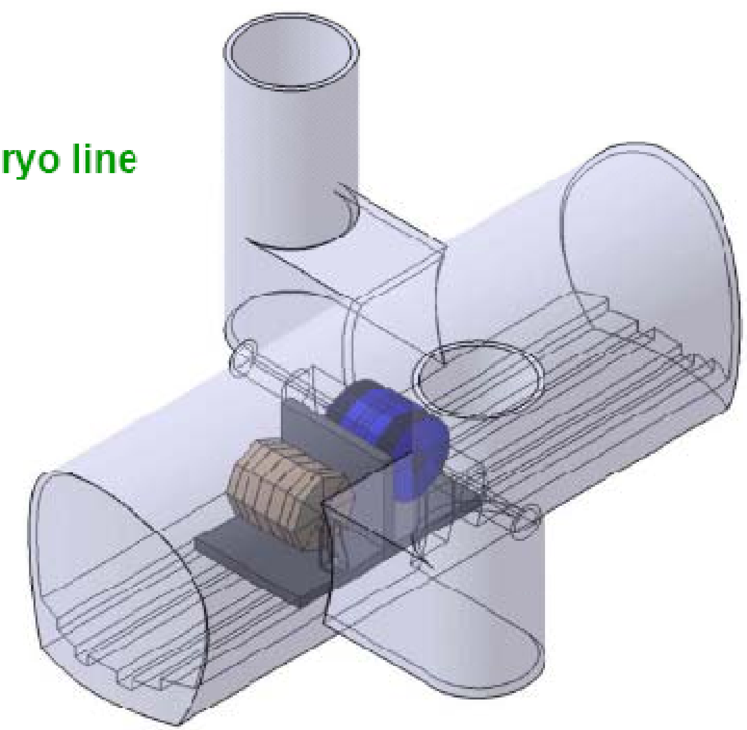
The Desy integration group can covert Catia step files to IDEAS…

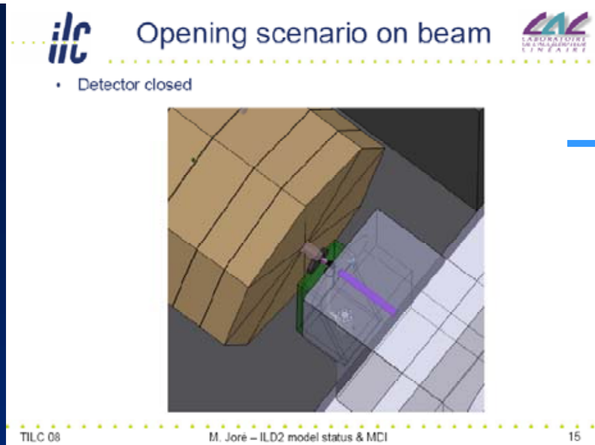


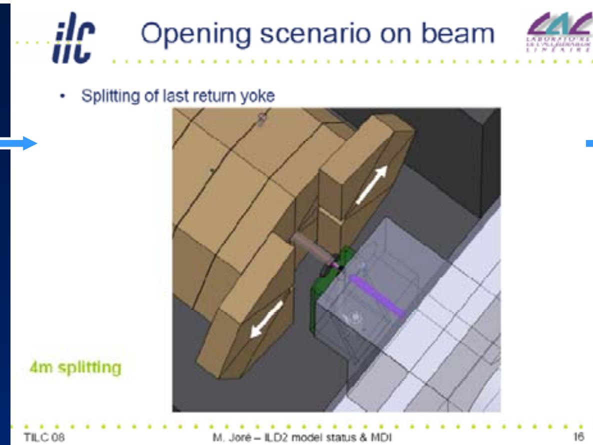
More by Mattieu Jore on integration…

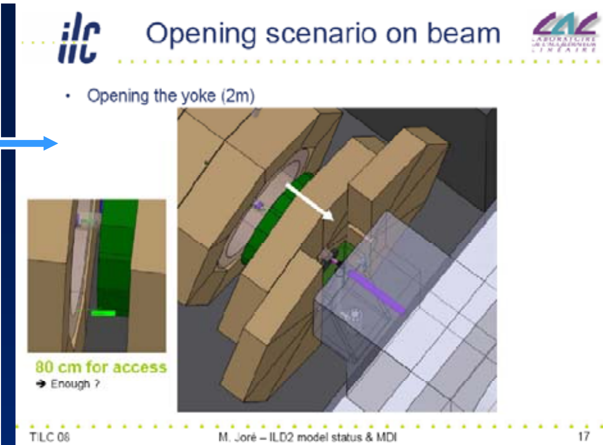
MDI

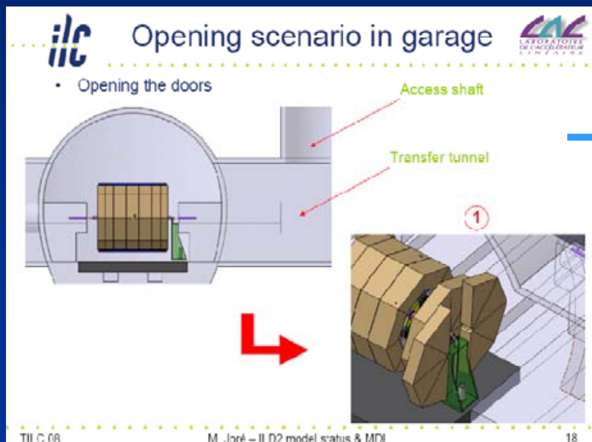
- ILD detector in ILC Cavern *(based on RDR & IRENG07 dimensions)*
  - **Push-Pull platform**
  - **Shielding Wall**
  - **QF1**
  - **Service Cryostat & Cryo line**

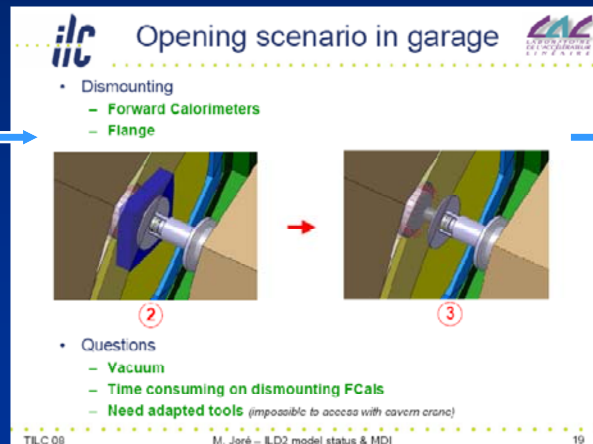



Opening scenario on beam
Detector closed
TILC 08
M. Joré – ILD2 model status & MDI
15


Opening scenario on beam
Splitting of last return yoke
4m splitting
TILC 08
M. Joré – ILD2 model status & MDI
16


Opening scenario on beam
Opening the yoke (2m)
80 cm for access
➔ Enough ?
TILC 08
M. Joré – ILD2 model status & MDI
17


Opening scenario in garage
Opening the doors
Access shaft
Transfer tunnel
1
TILC 08
M. Joré – ILD2 model status & MDI
18


Opening scenario in garage
Dismounting
– Forward Calorimeters
– Flange
2
3
Questions
– Vacuum
– Time consuming on dismounting FCals
– Need adapted tools (impossible to access with cavern crane)
TILC 08
M. Joré – ILD2 model status & MDI
19


Opening scenario in garage
Move back the EndCap & Cryo supply platform
4
Questions
– Movement of all services/cables
TILC 08
M. Joré – ILD2 model status & MDI
20


Opening scenario in garage
Access to Inner detectors with adapted tooling
TILC 08
M. Joré – ILD2 model status & MDI
21

No Conclusion

- Many correlated/challenging issues
- Nevertheless progress by our excellent and highly motivated machine physicists is evolving well
- Iterating on engineering designs
- W.I.P., 'interface' (='integration'?) document April 2009 will be very significant (will it give 'Master Lists'?)